AGRICULTURAL ENGINEERING

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THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Prefabricated, Small Plywood Grain Bin

The operating efficiency of many poultry men or small scale livestock feeders may be materially increased by conveniently-located grain storages.

A simple prefabricated plywood grain bin, 8′ x 8′ x 8′ in size, with 400 bushel storage capacity, may be used in a number of ways.

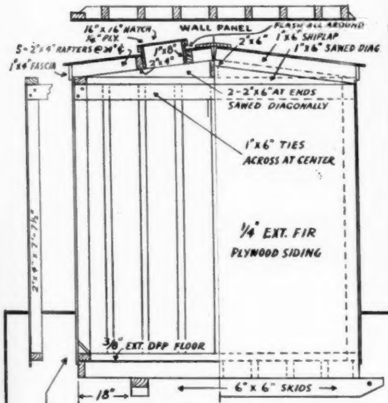
Five 8′ square panels for the floor and four walls, as shown in the photograph, make a bin to be placed inside of the poultry house or barn. If placed on the second floor, a gravity chute cut into the bin floor can discharge into a first floor hopper. Two experienced men should easily construct the panels in three days and assemble them in two hours. Estimating labor costs at $6.00 per man-day and allowing normal retail material prices gives a total cost of about $100, or 25 cents per bushel capacity.

The same structure with the addition of skids and roof, (as shown in the drawing), makes a field or feed lot bin. A portable elevator may be used to load or unload the bin. A homemade elevator of suitable length and constructed with plywood trunking will be light enough to be handled by one man.

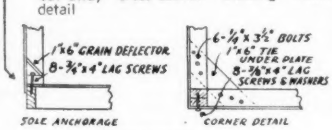
Setting several bins on a concrete foundation with adjoining concrete pit and vertical elevator makes a small two to four bin elevator of 800 to 1600 bushel capacity as shown in the sketches. The elevator, 20′ high, is a simple construction job using plywood trunking.

A short-time loading test to prove the bin design was conducted by filling the bin with wheat, one of the heavier grains. Results after three days, as published in AGRICULTURAL ENGINEERING, June 1943, show that the plywood deflection between studs was only about 1/8″. Maximum deflection in the studs was 5/16 inch.

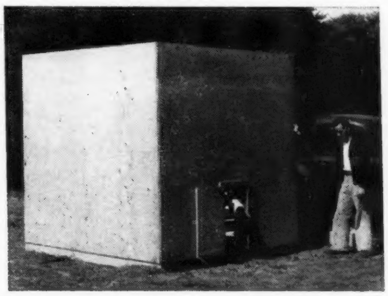
Construction details are available from the University of California, Plan C-531.



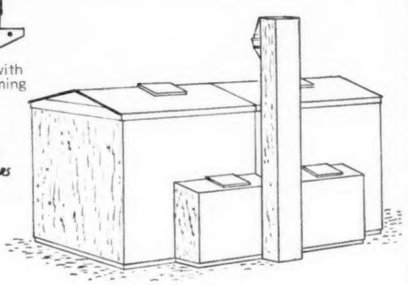
Side view of the plywood grain bin, with cut-away cross-section showing framing detail



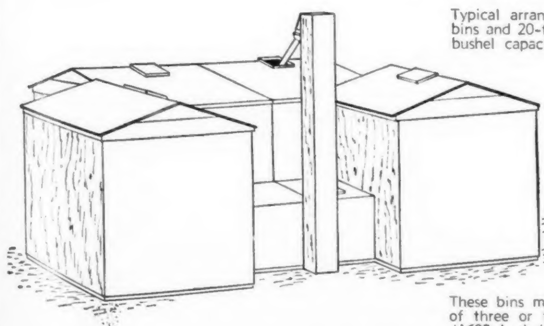
Detail of sole anchorage and corner construction



The completed, assembled plywood grain bin used in test at the University of California



Typical arrangement of plywood grain bins and 20-foot vertical elevator (800 bushel capacity)



These bins may also be used in series of three or four as illustrated above. (1600 bushel capacity)

BIN SPECIFICATIONS

Floor

6″ x 6″ x 9′0″ skids. 2″ x 6″ joists and header, with 2″ x 4″ center bridging. 3/8″ x 4′ x 8′ Exterior SoIS grade plywood nailed with 6d nails spaced 6″ o.c. for flooring.

Walls

1/4″ x 4′ x 8′ Exterior SoIS plywood panels nailed in vertical position over 2″ x 4″ studs 12″o.c. and 2″ x 4″ plate and sole with 6d galv. nails 4″o.c. Space 3/8″ x 4″ lag screws 12″o.c. to fasten sole and corner joints. Bolt 1″ x 6″ diagonal ties under plate across corners and 1″ x 6″ cross ties at center.

Roof

Rafters 2″ x 4″ spaced 24″o.c. and covered with 1/4″ x 4′ x 8′ Exterior SoIS Douglas fir plywood laid across rafters. Fill gable ends with 1″ x 6″ shiplap covering over top of plywood wall panels, and cover ridge with two 1″ x 6″ ridge boards.

Painting

Paint walls and roof with best quality exterior paint.

DOUGLAS FIR PLYWOOD
LARGE. LIGHT. STRONG.
Real Wood PANELS

Douglas Fir Plywood Association
Tacoma 2, Wash.

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR MAY, 1946

Vol. 27, No. 5

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Chicago, 2: DWIGHT H. EARLY
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EDITORIAL

Progress via Teaching Route

IN THE current gold rush, one large nugget of real opportunity seems to be going begging, at least according to some reports.

That opportunity is in teaching. The A.S.A.E. Personnel Service reflects an active demand for teachers in agricultural engineering, and only a few young men indicating any interest in this phase of the work.

It is time to discount musty jokes about the absent-minded, impractical professor, to their limited value as warnings of human weakness to which we all are susceptible.

It is time to recognize that, in the professions, practically all of the top leaders, and men on their way up, are teachers in the truest sense of the word. Success in dealing with the human factor demands it. And men in the educational field are among the leaders in the professions.

It is time to stop thinking of teaching as a procedure or a routine job, and to start thinking of it as an achievement—an accomplishment which is the result of many procedures and other influences. Teaching has been done only when someone has been helped to learn. A teacher is one who helps others to learn, regardless of his employment, location, position, profession, vocation, age, or his own degree of learning.

It is time to recognize, and help young agricultural engineers to realize, that a few years of college teaching offer a great opportunity for personal and professional development. It encourages the profitable habit of continued study and learning. It provides continued contact with youth and with leaders in this and other branches of engineering, in agriculture, in research, and in business, industry, and commerce. It may provide opportunity for original work in some phase of teaching, or in research, public speaking, writing, or invention, for professional recognition or financial profit.

It provides some foundation for the most difficult teaching job of all, which often arises in engineering practice and administration, and on which the success of a specific project and individual may largely depend — the teaching of some specific fact to some few or few thousand individuals who may range from illiterates to doctors of philosophy; who may have only a latent trace of remaining desire or ability to learn; who may wield tremendous influence; and who, for reasons of their own, may prefer to believe and advocate something entirely different. There is a teaching problem — and it will arise repeatedly in the career of an engineer who is going beyond routine technician work — to make any engineer wish he had the background of a few years of professional teaching experience.

There is time enough, after a few years of college teaching, for the young agricultural engineer to decide whether he wants to apply his professional and educational training and experience to a lifetime career in public service, industry, or private practice; in continued teaching or in research, design, development, sales, management, administration, or some other direction. He will be better prepared to make a sound choice and to make the most of his choice.

During the past 30 years, a substantial number of agricultural engineers have gone into industrial or commercial work via the teaching route. We doubt if any of them regret their teaching experience. We believe most of them will agree that it has helped qualify them to obtain and hold better jobs than they might have obtained without it.

Opportunities in college teaching are too few to be available to all agricultural engineering graduates. And most of us lack the aptitude to ever become truly great teachers. But when teaching opportunities go begging while young agricultural engineers are looking for work, the apparent implication is that many of them are overlooking an enviable chance to improve their qualifications as agricultural engineers.

The St. Louis Meeting

ONE of the privileges of peace which agricultural engineers will appreciate is the return of the annual meetings of the American Society of Agricultural Engineers. It would be superfluous to urge attendance at St. Louis, June 24 to 26; all who can will be there.

This meeting will necessarily reflect postwar problems— the opportunities and responsibilities literally thrown at agricultural engineers by current world food shortages, scarcity and high cost of farm labor; the backlog demand for farm building materials and operating equipment; preparation to resume long-time programs in conservation, education, extension, research, and professional development; preparation to make peacetime use of warborn technical progress; preparation to be of maximum service in a world of changed conditions, difficult readjustment, and enlarged opportunity.

It will reflect a state of flux among agricultural engineers, with men returned to this field from other war work present to reacquaint themselves with its personalities, technical progress, and current problems. Many men will be in new positions taken since the last meeting. Some will be looking for new talent, or for new positions.

Briefly, it will be a time for finding out "who's who and what's what" today in agricultural engineering, for lining up and getting set for a long, hard, and we hope successful, pull toward a sound peacetime prosperity — individually, professionally and as a factor of increased importance in the economic and social development of whole communities.

Farm Work Simplification

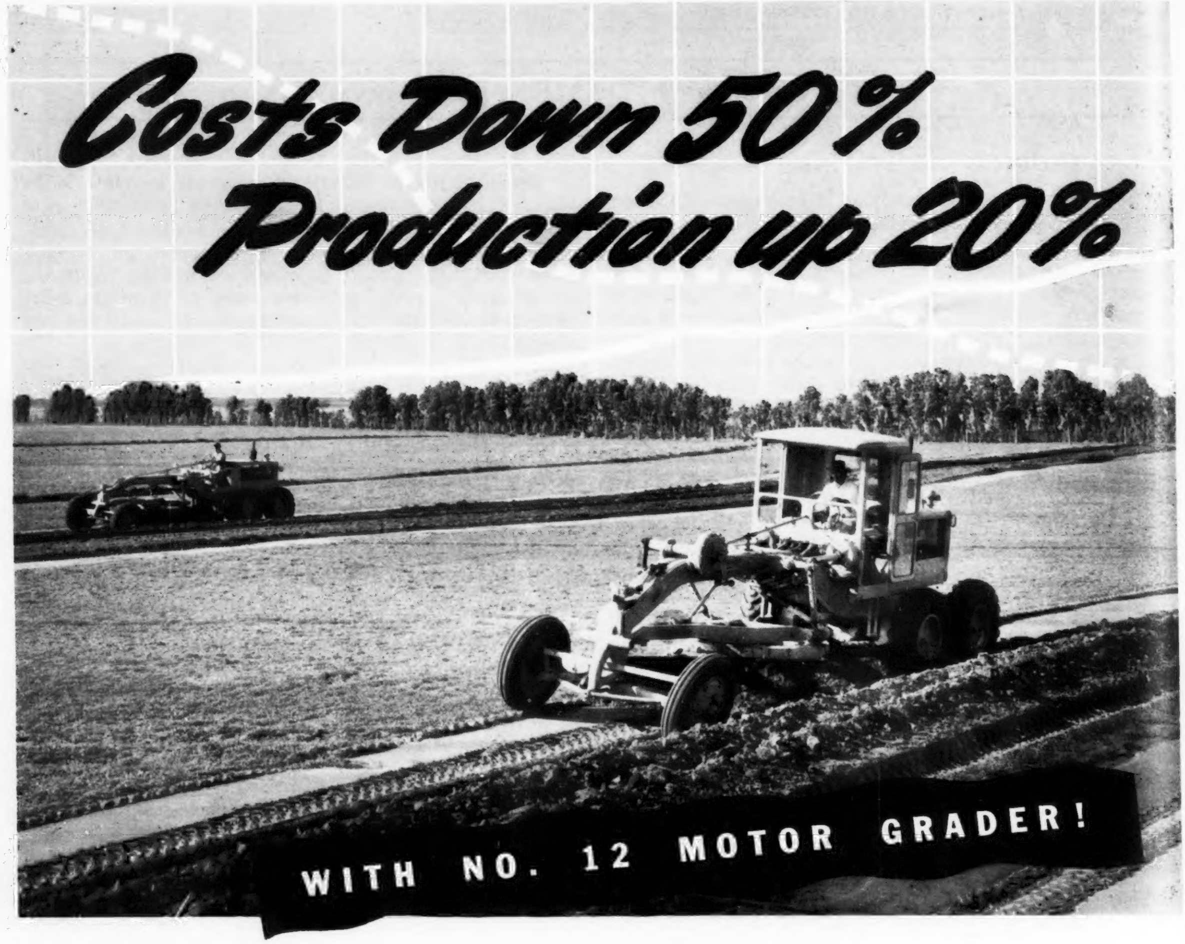
A SIGN of the times is a marked increase in interest in farm work simplification. Farmers are thinking in terms of producing more dollar value with less labor. They are ready to cut some corners which they have been walking around needlessly for years.

It is a wide-open field. No one has a monopoly on originality. Most farmers have some good labor-saving practices, original or borrowed, and the best farmers are more than ever searching for any labor-saving opportunities which they may have previously overlooked.

All farm work simplification is not engineering. Some of the opportunities in this direction are in management, shop practices, and the applied biological sciences. But it is right down our alley, and we may do well to see wherein agricultural engineering can help along the good cause.

Farm work which requires a lot of labor is readily identified by types — chores, hand picking, plant and animal care, hand and leg operations, repair jobs.

From an engineering viewpoint farm work simplification is one phase of labor saving. It is the farm practice, method, or use phase of mak- *(Continued on page 222)*



KING RANCH, Kingsville, Texas, has a "good start" on its terracing program with over 200 miles built to date. "Caterpillar" Diesel No. 12 Motor Graders have proved they are the most efficient units for this work.

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AGRICULTURAL ENGINEERING

VOL. 27 MAY, 1946 No. 5

Air Flow in Drying Baled Hay with Forced Ventilation

By R. C. Miller
MEMBER A.S.A.E.

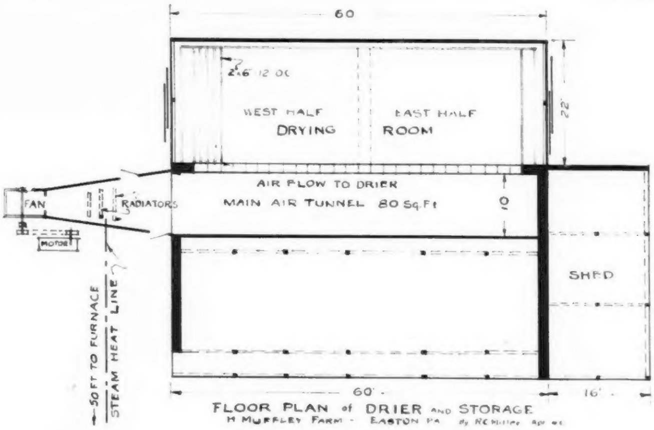
DRYING baled hay with forced natural-air ventilation is not as easily accomplished as drying long loose hay; however, successful experience should be a good illustration of the factors and principles involved in the design and operation of a baled hay drier. The experience of Herbert Muffley in designing, constructing, and operating a baled hay drier, which proved quite successful in 1945, may thus serve as an example to farmers, salesmen, and engineers. Mr. Muffley produces alfalfa hay on 78 acres of his 80-acre farm near Easton, Pennsylvania.

The first and very important thing Mr. Muffley did was to get information concerning the practice and methods of mow drying long hay. He attended the A.S.A.E. hay drying conference held at Knoxville, Tennessee, in December, 1944, and this gave him an opportunity to observe installations and the results of the method. My first interview with him was in the spring of 1945 when he drove to Columbus, Ohio, to get help in organizing a program of design and operation for his farm. He came prepared to give information on the amount of hay he had to cure in a season and also the equipment he had available for drying, handling, and storage. So far he had already done much more than we could expect the average individual to do in planning a hay drier.

The 78 acres of alfalfa had been producing about 100 tons or 3,000 bales of air-dried hay in each of the first and second cuttings. The third cutting produced about one-half that much. Mr. Muffley preferred a system where he could dry the hay in a certain place and then move the bales to his main storage. If each batch is dried in about seven days, then there could be at least two batches for each cut-

This paper was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946.

R. C. MILLER is professor of agricultural engineering, Ohio State University, and associate agricultural engineer, Ohio Agricultural Experiment Station.



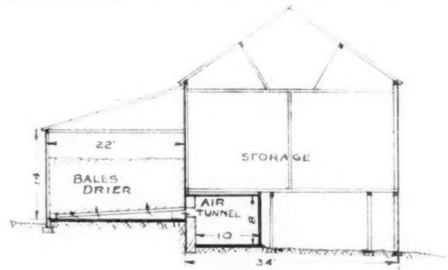


Fig. 1 *(Left and above)* Floor plan and section of drier and storage for baled hay on the Herbert Muffley farm in Pennsylvania. *(Below)* Hay baling, transporting, drying and storage equipment on the Muffley farm. The baler picks up the hay from the windrows, and the bales are delivered directly to the trailer wagon. In the background is the Dutch-type overhanging barn used for storage, with the drier shed at the right. The heating plant is located at the end of the shed at the extreme left, about 30 ft south of the barn

ting. Thus the drier should handle about 1500 bales in each batch. Results of the 1944 Purdue University studies indicated that bales should not be stacked over five or six tiers high in the drier. This gave a basis for the size of drier and storage structure needed.

The storage buildings on the Muffley farm consisted of a "Dutch" type overhanging barn 34x60 ft with a 16-ft shed across the east end (Fig. 1). This barn has a gable roof on 18-ft posts above the hay mow floor. A 9-ft ceiling on the first floor provided room for the main air tunnel. He planned to add a drying room 22 ft wide and 60 ft long as a shed on the north side of the barn. This provided 1250 sq ft of floor area in the shed for drying baled hay. About 270 bales, 16x42 in in size, could be placed in one tier. The 14-ft high outside wall provided enough height for eight to nine tiers and an air chamber underneath the bales.

Mr. Muffley had a single-inlet, forward-curve, multi-vane-type fan with 60-in diameter rotor to provide air, which was to be driven by a used automobile engine which could deliver at least 50 hp by belt to the fan. This large-size fan with adequate power satisfied a first essential of successful hay drying, which is an abundance of air forced through the hay. This size fan should deliver from 50,000 to 80,000 cfm (cubic feet per minute) of air, the capacity varying with the resistance and speed of operation.

THE RATE OF DRYING INCREASES WITH THE INCREASE IN TEMPERATURE

The rate of drying increases with the increase in temperature; therefore, extra heat might be used although it might be a fire hazard. He had in mind using a small, low-pressure steam boiler with 18x48-in grate area to heat the air. I calculated this boiler would heat the air about 5 F. This hard coal heater would be located about 30 ft from the barn to eliminate the fire hazard. The steam would be delivered to ordinary house heating radiators placed in the main tunnel near the fan outlet (Figs. 1 and 2). It was the large supply of air available rather than the amount of heat that led me to encourage him to continue planning to dry baled hay. If the fan delivered 75,000 cfm to a drying area of 1250 sq ft, it would provide 60 cfm per sq ft of floor area. This is about three times the amount of air used in the Purdue University experiments reported for 1944. This provided a reasonable factor of safety.

With ample air provided, the next problem of designing the system was to get uniform air distribution to the hay. To deliver 80,000 cfm of air at a tunnel velocity of less than 1,000 fpm (feet per minute), as recommended for the large tunnel system, would require a main tunnel at least 80 sq ft in area. Such a large tunnel could be constructed at one side of the first floor of the barn, between the first row of posts and the outside wall. It was therefore built 10 feet wide and 8 ft high. The air is delivered from this tunnel to the air distributing space under the hay through openings into the shed at its floor level (Fig. 2). Mr. Muffley thus carried out the design as fully as possible. A few details of construction may help explain the operation.

The drying shed was constructed of rough sawed hemlock lumber for framing and siding. Because of the slope of the ground, the concrete floor of the shed was about three feet higher than the floor of the main barn. This placed the openings from the main tunnel to the air space under the slatted floor in the shed about halfway up the side of the tunnel (Fig. 2). The air space under the bales was formed by placing 2x6-in joists 24 in on centers over the concrete floor (Fig. 3). These joists rested on blocks which raised the top edge to a height varying from 14 in at the tunnel side to 10 in on the back side. The joists were covered with 1x3-in slats placed 12 in on center to support the bales. Only the end and middle slats were nailed, leaving the other slats movable for cleaning. The joists were covered with paper for a width of about 15 in along the tunnel wall to reduce air leakage. A partition of the air space at the center divided the drier into two sections.

After the second alfalfa cutting was cured and removed to the main mow storage, an additional joist was placed between each pair of joists to make the spacing about 12 in on center. This arrangement eliminates the need for slats on top of the joists. The bales are placed directly on top of the joists, which provides more convenience and safety in handling the first tier of bales. The joists are not nailed so they may be quickly removed to permit using the drying area for storing machinery. The tunnel may also be used for storage.

The fan, tunnel, and drying room arrangements are illustrated on the plans. The 60-in, forward-curve, multi-vane, single-inlet fan (Figs. 1 and 4) was placed about 20 ft from the barn with a tapering tunnel connecting it to the main air tunnel. The entire air tunnel was lined with 4x8-ft panels of a commercial product known as "Homosite". In the space between the fan and the main tunnel were placed the steam radiators for heating the air. Hot water radiators were also placed above the steam radiators. The water from the cooling system of the automobile engine used for power to drive the fan is circulated through these radiators. This serves the double purpose of cooling the engine and heating the air.

Mr. Muffley reports that, when both the furnace and engine-cooling heat were used to heat the air delivered to the hay, the rise in temperature of the air was about 7 F. When only the heat from the engine cooling was used to heat the air, the temperature rise was from 2 to 3 F.

The furnace heating was used only between 9 p.m. and 6 a.m. while drying the first cutting of alfalfa, and it was used only part of the time during the curing of the second cutting. It was not used at all while curing the last cutting in October when the air temperature was low. The furnace was handstoked at intervals of about 30 min throughout the night. This is an example of the attention Mr. Muffley gave at all times to the proper operation of all factors in his mow drying system. It also indicates that it is easier to provide more air than extra heat.

On August 31 and September 1, 1945, the second batch of the second alfalfa cutting was dry and ready to move to storage. The drying started as soon as the hay was cut. A 7-ft mower attached to an old automobile was used to cut the hay. The hay was usually cut in the late afternoon and evening and windrowed the next day, weather permitting. Often the weather was so rainy that the hay could not be handled for a day or two after cutting. Baling operations usually started in the afternoon and evening and sometimes continued to beyond midnight.

MOISTURE CONTENT OF THE HAY VARIED FROM ALMOST DRY TO AS HIGH AS 60 PER CENT

The moisture content of the hay varied from almost dry to as high as 60 per cent (Table 4). Mr. Muffley's description of the operation during the third cutting in October is typical: "The alfalfa was cut on Thursday afternoon and evening. On Friday it rained until 10 a.m. After dinner we started windrowing with the side-delivery rake. The next morning at 9 o'clock we baled the hay. There was very little sunshine. I believe the moisture content ran between 50 and 55 per cent."

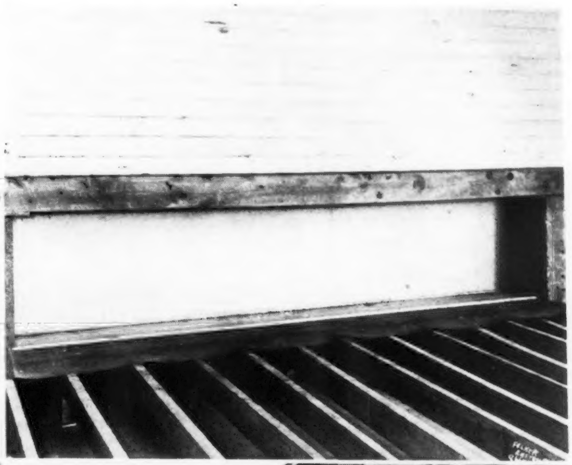
A Holland baler using twine for ties made bales 16x18x42 in in size, or a volume of 7 cu ft. Usually the bales were as tight as the baler would make them. In checking

the 26 bales that were dried in the second cutting (Table 4), the moisture contents ranged from 27 to 60 per cent on an air-dry basis, with an average moisture content of 45 per cent. The weight of the bales ranged from 69 to 115 lb as placed in the mow, and were dried to a range of 44 to 70 lb. The average weight of the 26 bales as placed in the mow was 90 lb, or 13 lb per cu ft. The weight when dry was 55 lb, or 8 lb per cu ft. The average moisture content on an air-dry basis was 39 per cent. If we assume the hay had actually 10 per cent moisture when air dry, its average moisture content as placed in the mow averaged 45 per cent.

Since drying is the removal of moisture by air, the effect of moisture content of the hay on the amount of water to be removed deserves attention. Fig. 6 illustrates the amount of moisture in pounds that must be removed to make a ton of hay containing 20 per cent moisture. The column for 35 per cent moisture shows 460 lb must be removed. With 45 per cent moisture, 910 lb, or almost double the amount of moisture, must be removed as compared with 35 per cent. If a plant is designed to dry hay at 35 per cent moisture, it would require twice as much air to dry hay at 45 per cent moisture. Since some of the hay had 55 per cent moisture when placed in the drier, 1550 lb of water would have to be evaporated. It would require at least three and a half times as much air to dry at the same rate as hay containing 35 per cent.

Since there may be a greater loss of air between bales for a given mass of baled hay as compared to drying a similar mass of long loose hay, it is important to allow a large factor of safety in air supply. At least four times as much air should be provided to dry the baled hay which may come in at 50 per cent moisture than has been used in drying long hay containing 35 per cent moisture. In Mr. Muffley's operations the amount of air delivered to the hay easily met this requirement.

The amount of air delivered to the hay on August 31 and September 1, after the second cutting was dry, ranged from 60 to 115 cu ft per sq ft of floor area. This variation



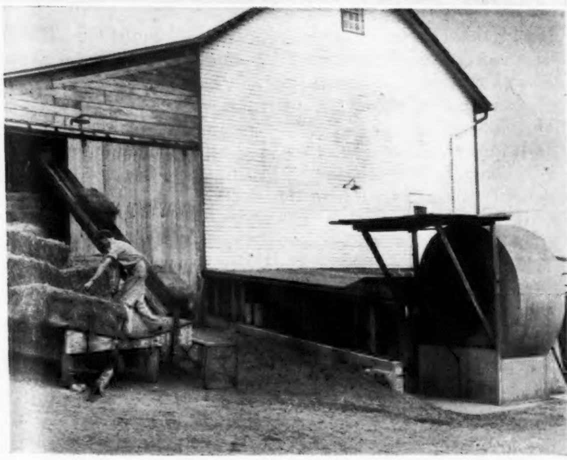


Fig. 2 *(Upper left)* Inside view of the main air tunnel which is 8 ft high and 10 ft wide. The 26 openings to the drier are at the right just above the stone foundation. The radiators in the background are in front of the fan outlet • Fig. 3 *(Upper right)* This shows the 2x6-in joists spaced 12 in on centers which support the bales in the drier and form the air distribution space (plenum chamber) under the hay. It shows the end near the main air tunnel. The heavy paper covers the joist about 15 in wide along the main tunnel wall to prevent excess air escaping along the wall. The air chamber extends to within a similar distance from the outside walls • Fig. 4 *(Lower left)* The bales are moved from the trailer to the drier by a simple conveyor that has a capacity of 6 bales per minute. The top bale on the conveyor is passing to another conveyor which carries the bales horizontally. These conveyors are also used to move the dry bales from the drier to storage in the large mow. When removing the bales from the mow, the rotation of the conveyors is reversed. The fan and tunnel leading to the main air tunnel are at the right • Fig. 5 *(Lower right)* This picture is another view of the conveyor shown in Fig 4, showing the motor at the lower end of the conveyor. Both upper and lower conveyors are controlled with the same switch. The slats supporting the bales are visible at the bottom of the drier. The bales in alternate tiers are placed in cross direction to block air passage space between the bales

was due to different heights of hay and to different pressures used. The drier was loaded to an average height of eight bales, or 12 ft, over the entire drying shed area of 1250 sq ft. The height of bales ranged from 7 tiers for the east half to 8 and 9 tiers for the west half of the 60-ft long drying shed.

The air distribution space under the hay was divided at the center so that all the air might be directed from the main tunnel to either half or to the total area. Each half had a floor area of about 625 sq ft.

Manner of Air Flow Tests. The air velocity readings were made with an anemometer held in the air stream. The readings were made at each opening from the tunnel to the air space under the hay. There were 13 openings for each section, or a total of 26 openings. Each opening was about 14x22½ in, or 2.2 sq ft in size. This gave an intake area of about 28.6 sq ft for each section, or a total of 57.2 sq ft for the entire area. There are panel slides for closing each opening to any amount desired, so that either section could be closed.

After the first reading, where all the openings were open, most of the readings were taken at the east section. The bales were removed from that section a tier at a time. This permitted taking data on air flow, pressures, and fan speed at intervals of one tier from tier 7 at the top to the bottom, with the exception of tier 6.

The air pressure reading in inches of water was made with a U-shaped monometer tube located near the middle of the south wall of the tunnel. A revolution counter was used to get the rpm of the fan. This speed was also checked against the miles per hour recorded on the speedometer on the engine.

Wileman[1] found that the resistance to air flow dropped about 0.15 in as the baled hay dried from about 32 to 10 per cent moisture. This drop was from 0.9 to 0.75 in for the first cutting and from 1.0 to 0.85 in for the second cutting, or about 15 per cent. This decrease in resistance is accompanied by an increase in air flow. Thus the readings of air flow which I took with dry hay were possibly about 15 to 25 per cent greater than exist when the hay is tough or at the start of drying.

Amount of Air per Square Foot of Floor Area. With air pressure equivalent to 0.7 in of water, the total volume of air delivered to the entire area was 70,800 cfm, an average of 57 cfm per sq ft of floor area. The east half, with 7 tiers of bales, received about 37,800 cfm, or 60.5 cfm per sq ft of floor area. The west half, with 8½ tiers, received 33,100 cfm, or 53.0 cfm per sq ft of floor area. An increase of about 20 per cent in height of the bales reduced the air flow about 14 per cent at 0.7 in pressure. This indicates a greater per cent of air passed outward at lower levels of the sidewall surface than passed through the top where the height was 8½ tiers as compared to 7 tiers.

If we figure the entire surface for sidewalls and top of each section, there were about 1950 sq ft for the 8½-tier section and 1700 sq ft for the 7-tier section. This gave an average of 17 cfm of air per square foot of surface for the 8½-tier section as compared to 22.2 cfm for the 7-tier section. This is an increase of 30 per cent for the 7-tier over the 8½-tier.

Number of Tiers of Bales and Air Movement. The bales in the east section of the drier were removed a tier at a time during the test so that readings could be made at tier intervals. The velocity of air escaping at the top surface was measured with the anemometer in a 10-to-1 multiplier box placed tightly against the surface. The volume of air delivered under the hay was much greater than the amount escaping at the top. This difference is accounted for by air escaping to the sides. This amount is roughly determined by subtracting the volume of air escaping at the top from the total delivered under the hay. These figures are given in Table 1, and are illustrated in Fig. 7. This shows a greater total volume loss to the sides than to the top with more than 5 tiers of bales. Line B-B′ shows the loss at the top in cubic feet per minute per square foot, and line D-D′ shows the loss to the sides. Line A-A′ shows the volume of air delivered per square foot of floor area. The delivery was fairly constant for the test. It ranged from 96 to 110 cfm. Line C-C′ shows the average loss for the total surfaces of side and top.

Lines B, C, and D cross at about same point, near the 5 to 6-tier height of bales. This indicates that the best balance of air distribution to top and sides is with heights of 4 to 6 tiers.

The per cent of air escaping to the top is given in Table 2. It ranges from 17 per cent for 8½ tiers to 86 per cent for one tier. About 50 per cent escaped to the top with 4 to 5 tiers.

[1]Progress Report of Mow Curing Studies, by R. H. Wileman, Purdue University Agricultural Engineering, Mimeograph No. 3, November, 1944.

TABLE 1. VOLUME OF AIR DELIVERED TO ONE SECTION OR 625 SQ FT OF FLOOR AREA, AND VOLUME OF AIR ESCAPING AT TOP AND SIDE SURFACES WITH DIFFERENT NUMBER OF TIERS OF BALED HAY IN THE DRIER*

Column or Number	1	2	3	4	5	6	7
1 Number tiers of bales in drier	1	2	3	4	5	7	8½
2 Pressure under bales, inches of water	0.5	0.85	1.00	1.20	1.25	1.30	1.30
3 Total cfm	68570	68060	62970	59000	59270	60450	60060
4 Delivered cfm per sq ft floor area, (cfm ÷ 625 sq ft)	110	109	101	96	96	96.7	96.2
5 Total surface area, sq ft	778	931	1160	1237	1390	1700	1950
6 Top surface area, sq ft	625	625	625	625	625	625	625
7 Side surface area, sq ft	153	306	535	612	765	1075	1325
8 Cfm per sq ft at top surface (measured)	95	80	65	55			16.5†
9 Cfm per sq ft of total surface‡	80	67	54	50	45	35	31
10 Cfm per sq ft of sides only; top deducted from total	60	59	41.7	40.2			40.8

*No readings were taken with only 6 tiers in drier.

†The volume was 15 cfm with 9 tiers and about 21 cfm for 8 tiers.

‡The total surface includes all side surface area plus the top area as given in line 5. Line 3 is divided by line 5.

TABLE 2. COMPARISON OF THE TOTAL VOLUME OF AIR ESCAPING AT TOP SURFACE AND SIDE SURFACE WITH DIFFERENT NUMBER OF TIERS OF BALES

Number of tiers of bales	Pressure in tunnel*	Total volume of air, cfm: Delivered under hay	Escaping: Top	Escaping: Side	Per cent of air volume escaping top surface
8½	1.3	60,060	10,000	50,060	17
7	1.3	60,450	17,500†	42,950	29
5	1.25	59,970	26,875†	33,095	45
4	1.20	59,000	34,375	24,625	58
3	1.00	62,970	40,625	23,345	64.5
2	0.85	68,060	50,000	18,060	73
1	0.50	68,570	59,375	9,195	86

*Expressed in inches of water.

†The volume escaping for tiers 5 and 7 is estimated from the curve B-B′ of Fig. 7.

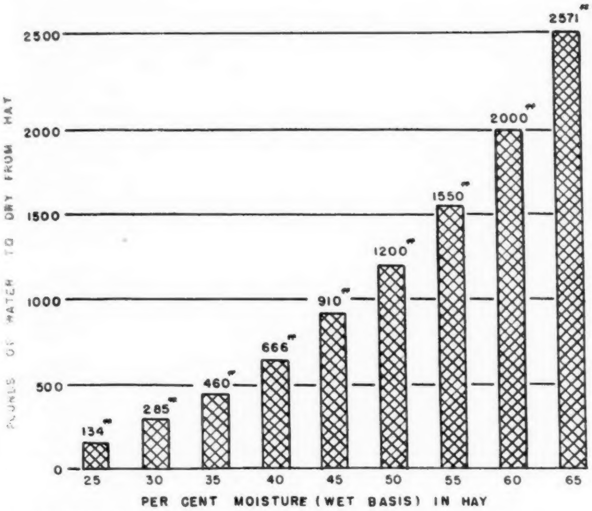


Fig. 6 This chart shows the amount (pounds) of water that must be removed from hay (in forced air drying in the mow) at various moisture contents, to make one ton of dry hay with 20 per cent moisture

Air Movement in Main Tunnel. The large main air tunnel, 8x10 ft, or 80 sq ft in area, reduced the velocity of air from the fan to an average of less than 1000 fpm (feet per minute). This would have a velocity pressure of only about ⅛ in. With the basic principle that $VP = VP$, it is evident that the velocity pressure at the fan outlet is changed to static pressure in the main tunnel in so far as the velocity of air is reduced. By having fairly uniform pressure in the main tunnel, there is a similar uniform air velocity from the main tunnel to the side flue openings, leading to the space under the hay. The area of the openings to the side flues or air chamber under the hay is about one-third to two-thirds of the cross-section area of the main tunnel. For example, the total area of the 26 openings was 56.6 sq ft as compared to 80 sq ft for the main tunnel. When air was directed to only one-half the drier, only 13 openings were used. This was an area of 28.3 sq ft.

An estimate of the air pressure under the hay may be obtained by deducting the velocity pressure of the air moving from the main tunnel under the hay from the static pressure in the tunnel. Table 3 gives this estimate for various numbers of tiers of bales.

TABLE 3. ESTIMATE OF AIR PRESSURE UNDER HAY IN DRIER WITH VARIOUS TIERS OF BALES

Number tiers of bales over drier	Average velocity of air from tunnel to hay, fpm	Equivalent velocity pressure*	Tunnel pressure†	Estimated pressure under hay tunnel (velocity)†
1	2423	0.37	0.5	0.13
2	2406	0.36	0.85	0.5
3	2225	0.31	1.00	0.7
4	2087	0.27	1.20	0.93
5	2120	0.28	1.25	1.0
6	2100	0.28	1.30	1.0
7	2100	0.28	1.3	1.0
8½	2103	0.28	1.3	1.0

*This pressure, expressed in inches of water is based on the formula $V = 4000\sqrt{h}$ where V is the velocity in feet per minute and h is the pressure in inches of water. This is at an air temperature of 65 F and barometric pressure of about 29 in.

†Expressed in inches of water.

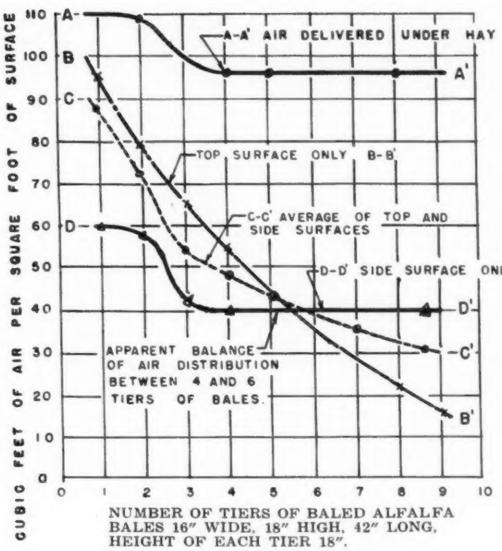


Fig. 7 This chart shows a comparison of the amount of air escaping at the top surface and the total outside surface (in cfm per sq ft) with different numbers of tiers of bales — the volume of air being fairly constant, varying from 97 to 110 cfm per sq ft of floor area

With only one tier of bales, the velocity of air from the main tunnel to the hay area was 2423 fpm. This is a velocity pressure of about 0.37 in. Subtracting 0.37 from 0.5, the main tunnel pressure, gives 0.13 in as pressure under the hay. This indicates, as one could imagine, that there was very little resistance to the air passing through one tier of bales. Contrast this with the resistance of 4 to 8 tiers. Where the tunnel pressure was between 1.2 and 1.3 in, the velocity pressure was 0.28 in, or roughly 0.3 in. This gives a difference of about 1.0 in pressure which would be the pressure directly under the hay.

It seems significant, with the amount of air delivered to the hay at tunnel pressures of 1.2 to 1.3 in, that the pressure under the hay was about the same for heights varying from 4 to 8½ tiers. Also the total volume of air was fairly constant with an increase in number of bales. This indicates that, when more than 5 tiers of bales were used, the added tiers received a smaller per cent of air and

TABLE 4. WEIGHT IN POUNDS PER BALE AND PER CUBIC FOOT AND MOISTURE CONTENT OF BALES WHEN PLACED IN DRIER, AND WHEN AIR DRY—1ST, 2ND, AND 4TH TIERS IN EAST SECTION OF DRIER, SECOND BATCH, SECOND CUTTING OF ALFALFA. MUFFLEY FARM, SEPT. 1, 1945

	No. of tiers	No. of bales weighed	Weight in pounds As stored	Weight in pounds Air-dry	Per cent moisture Air-dry basis	Per cent moisture Deduct 10% from air-dry
Average	1	9	94	49	48	53
Range			82 to 115	44 to 56	33 to 55	40 to 63
Weight per cu ft			13.5	7		
Average	2	10	82.5	53	35.8	41.3
Range			62 to 99	40 to 59	28 to 42	35 to 48
Weight per cu ft			11.8	7.6		
Average	4	7	93	65.2	32.0	39.0
Range			81 to 106	59 to 70		
Weight per cu ft			13.3	9.3		
Average for all bales		26	90	55	39	45.2

thus dried slowly. This seems logical and also accounts for some mold in some of the tougher bales in tier 9. These bales were still drying. Mr. Muffley moved the top three tiers from the west section to the bottom of the east section for more drying after the bales in the east section had been removed to the storage.

The bales are readily moved by means of simple homemade bale conveyors (Fig 4). The conveyors are used to convey the bales from truck to the drier and from the drier to the storage in the main mow. Each section of the elevator has its own $\frac{1}{2}$-hp electric motor which may be plugged into any available outlet. The removal of bales after each batch makes possible inspection of results.

Mr. Muffley had two batches of first cutting alfalfa, each from 5 to 6 tiers high. The first batch of the second cutting was also about 6 tiers high, while the second batch, as already stated, was from 7 to 9 tiers high. The third cutting also made a batch $5\frac{1}{2}$ tiers high.

Power Requirement. The power required to deliver the amount of air during the tests varied from about 28 to 48 hp. This is calculated from manufacturers' data taken for the volume of air pressure in the tunnel and revolutions per minute of the fan. The fan is a single-inlet, forward-curve, multivane type. This power requirement indicates that much more power should be available in drying baled hay than is commonly used in drying long loose hay.

Cost and Value. Mr. Muffley estimated the power cost for drying was about $3 per ton. He sold some of this hay for $60 a ton as compared to $45 per ton for some of his best field-cured hay.

Baled-hay drying by means of forced-air ventilation is possible. It does require a large volume of air. It seems a fair estimate to use about 60 cfm per sq ft of floor area covered with about 6 tiers of hay. The hay should not be placed over 6 tiers high; possibly only 4 to 5 tiers should be used.

With the method of placing the bales in the drier, as used by Mr. Muffley, the fan should be capable of operating against about 1-in pressure in the main tunnel. The hay was dried in less than seven days for first and second cuttings, so it seemed to dry at a rate rapid enough to prevent mold as suggested in C. E. Frudden's paper in AGRICULTURAL ENGINEERING for March 1946.

Good drying starts with uniform baling and fairly uniform moisture in the bales in one tier. Once in the mow it becomes a matter of supplying ample air at all times. Hay can be dried without extra heat. Extra heat may be used if proper fire protection is offered. The large main air tunnel seems necessary for uniform distribution of the air. The large main tunnel also permits directing air in various directions. For example, Mr. Muffley can extend the drying to the area under the main barn and also under the main mow storage by making more openings from the tunnel to the side or top. It seems desirable to have a continuous air chamber under the bales to distribute the air uniformly. That is, joist with slats or joists close enough (12 in on center) so that the bales rest directly on them seems good design for baled-hay drying.

Mr. Muffley's experience seems to be a good illustration of the principles and practices essential to baled-hay drying; at least, it may serve as an example until better practices are proven.

Discussion by R. C. Shipman

IN WORK on curing baled hay at Purdue University, a tight-walled mow section 20x20 ft was constructed on the mow floor of the University dairy barn. The sides of this mow section were made 10 ft high. A slatted floor was placed inside of this enclosure 6 in above the regular tight mow floor. This floor was made with 2x4's blocked off of the regular floor with 2-in blocks every 2 ft. Across the 2x4's, 1x3-in slats were placed to form the slatted floor, with $1\frac{5}{8}$ in space between the slats. Around the edges of the mow the slatted floor was sealed tight, 12 in from the wall, to reduce the amount of air escaping between the hay and the mow walls.

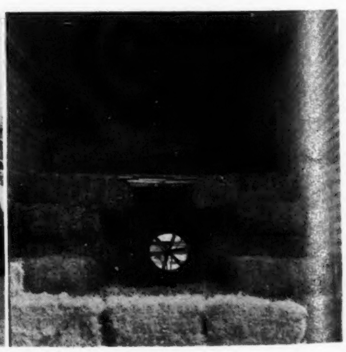
Across one side of the mow a main tunnel or plenum chamber 4x4x20 ft was constructed. The entire area between the mow floor and the slatted floor of the curing mow on the tunnel side of the mow was left open. This left an opening 6 in high and 18 ft long to allow air to pass from the distribution area under the entire floor.

With 7 layers of bales, or about 9 ft of depth, packed tight with joints between bales broken, an air volume of 4000 cfm, or 20 cu ft per sq ft of mow floor area, produced a resistance pressure of 1.5 in.

With 4 layers of bales over the system, an air volume of 10,000 cfm, or 25 cfm per sq ft of mow floor area produced a resistance pressure of 1.25 in. An even flow of air was obtained in all parts of the mow.

The accompanying pictures show the procedure of stacking bales to form a closed air tunnel as used at the Robert H. Murray farm, near Valparaiso, Ind., this past year. The two columns of bales on each side supported the weight of the three layers of bales on top. All joints between bales were broken and a 1x6-in board supported each bale over the center of the tunnel. All joints between bales were broken as in laying brick. A resistance pressure of 0.65 in was produced with an approximate air volume of 20,000 cfm. A very uniform flow of air was obtained in all parts of the tunnel.

R. C. SHIPMAN was formerly extension agricultural engineer, Purdue University.

The pictures at the right show the method of stacking bales on Robert H. Murray farm to form a closed air tunnel. The view at extreme right shows the tunnel construction used in piling the bales

Observations on the Resistance of Hay to Air Flow

By Andy T. Hendrix
MEMBER A.S.A.E.

THE investigations being conducted by the Farm Electrification Division BPISAE, of the U. S. Department of Agriculture in relation to hay drying include several factors which are related to this subject. The general objectives of the studies are to obtain fundamental engineering data in relation to hay drying, and to utilize these data in improving hay drier design and performance. Many investigators have been and are now engaged in hay drying work. Data are being gradually assembled, but in some phases of the work little reliable data are available.

Experimental Equipment and Procedure. In cooperation with the agricultural engineering department of the Virginia Agricultural Experiment Station, studies were initiated in the late summer of 1944 to obtain data relative to drying hay in the mow. One factor which was considered of major importance in hay drier design was that of resistance of hay to air flow. Very little information has been available on this subject, and consequently present work on hay drier design must be largely based on assumptions. In this study the resistance of hay to air flow was the principal factor to be observed.

A bin was constructed to be used as a hay mow and to facilitate determinations of resistance. The bin which was used for the 1944 tests was rebuilt for use in 1945. It was 8x8 ft, floor area, and 12 ft high. The inside corners were rounded to a 2-ft radius. The inside walls of the bin were smooth and were air tight. The floor was of 3-in slats spaced 6 in on centers and supported by floor joists. The outer portion of the floor was covered so that only one-fourth of the floor area was open for entry of air into the hay. The entire bin was mounted on scales so that the weight of the hay in the bin could be readily observed at any time desired. Thus the rate of moisture removal and total quantity of moisture removed could be easily determined. Total weight of hay could also be readily ascertained. A plenum chamber was provided underneath the slatted floor of the bin drier so as to reduce the effect of impact or velocity pressure of air before entry into the hay. To reduce further the effect of air velocity pressure within the plenum chamber a transition piece was constructed joining the air supply duct to the plenum chamber.

The air supply duct was constructed to facilitate reliable air volume measurements. The duct enclosed honeycomb straighteners, and a pitot tube traverse station was provided. Procedures followed in measuring air flow through the duct were substantially in accordance with N.A.F.M. (National Association of Fan Manufacturers) standards for determining fan performance. Air was supplied by a centrifugal blower equipped with variable-speed V-belt drive. Thus any pressure or volume within the capacity range of the blower and motor could be easily selected. Motor controls were provided so the fan could be operated on any desired schedule.

Various data were recorded during the several tests conducted. Both recording thermographs and thermometers were used to indicate temperatures. To determine relative humidities, both hand and motor aspirated psychrometers were used. Moisture contents of hay samples were determined by the oven method. Quantity of hay and rate of moisture removal were determined by weighing the bin and contents at intervals.

Static pressures in the plenum chamber under the hay were measured by means of a piezometer ring connected to an inclined manometer tube. Static pressures within the hay were determined by inserting a probe into the hay at the desired point and depth. This probe was a ¼-in pipe which was connected by means of rubber tubing to an inclined manometer.

Hay was manually placed in the bin. It was spread as uniformly as was practically possible, and was tramped around the outer edges and in the rounded corners to reduce excessive air flow at those places.

Rate of Air Flow Through Hay. It has been a common observation with forced-ventilation hay driers that considerable loss of air occurs along the edges of the hay mow. Also, the distribution of air flow through hay is not uniform. Anemometer tests of air flow from the surface of the hay in the bin drier showed a greater rate of discharge from the area along the walls than occurred from the central portion of the hay surface. Variations between the mean velocity of air flow along the bin walls and the mean velocity from the central portion of the hay surface were rather consistent.

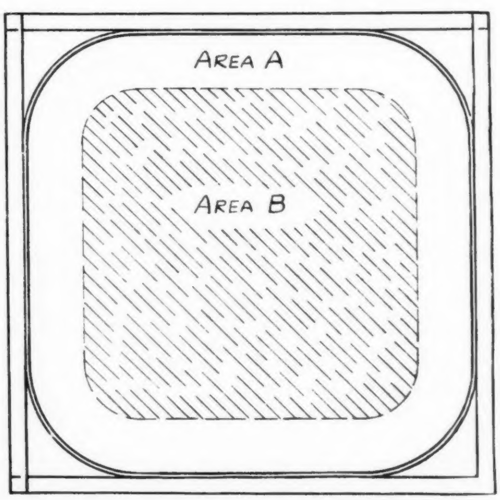


Fig. 1 Plan view of bin drier showing division of hay surface into two areas, A and B, for determining rate of air flow through hay

The procedure used to reduce, as far as was practically possible, the effect of air losses along the bin sidewalls was as follows: Several anemometer measurements of air flow along the walls were made in the area A, Fig. 1, and also in the area B. The means of the corrected values of the anemometer readings for each area, A and B, were then determined. Since there was no appreciable loss of air from the system, it was assumed that the mean anemometer reading for each of the areas indicated the relative rates of air discharge per unit of each area, and that the total air flow was indicated by the combined anemometer readings. The actual total volume of air flow was determined either by pitot tube or velome-

This paper, in substance, was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946, and is a progress report of cooperative research by the U. S. Department of Agriculture and the Virginia Agricultural Experiment Station.

ANDY T. HENDRIX is associate agricultural engineer, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

ter traverse of the air supply duct. By subtracting, on a proportional basis, the air discharge in area A from the total air flow as determined by traverse of the supply duct, the mean rate of air flow in area B was determined. While not absolutely accurate, this procedure allowed for air leakage along the bin walls, and was considered to be sufficient for practical results. This procedure was used for all air flow measurements made in the bin drier, and the funnel-anemometer combination, thus calibrated, was used in air flow measurements in field tests.

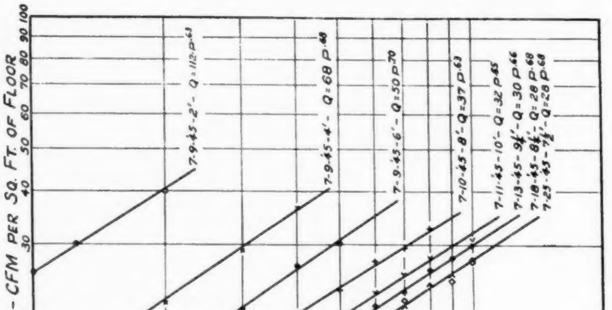
Moisture Content of Hay. Moisture content of the hay as placed in the bin was determined by taking composite samples of the hay and drying these samples in an oven as previously mentioned. After each lot of hay in the bin was dried to below 20 per cent moisture content, it was removed from the bin to provide space for further tests using the same experimental equipment.

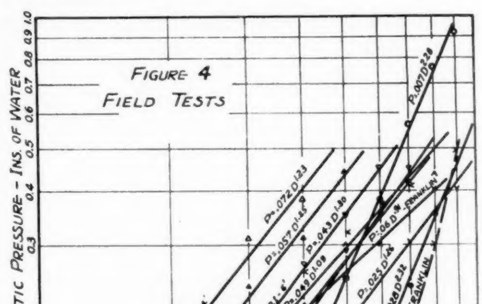
Drying of Hay in the Mow. Perhaps the most important immediate engineering consideration in mow drying of hay is the forcing of the necessary amount of air through the hay. The requisite amount of air to effect adequate drying within the permissible drying period will always depend on several factors. There seems to be fairly general agreement that the rate at which moisture is removed from hay in the mow depends primarily on two things:

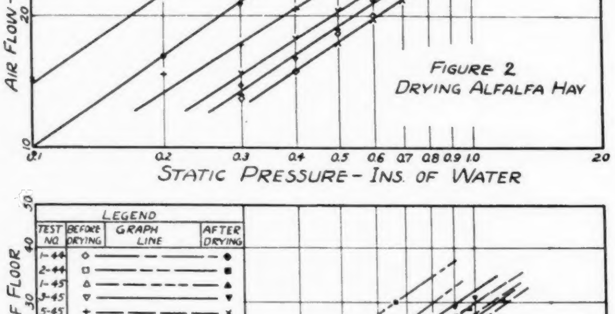
1 Condition of the air, i.e., its temperature, moisture content, etc.

2 Velocity of air flow through the hay.

Under drying conditions when the heat content of the air is the only source of heat for vaporization of moisture from the hay, the rate of evaporation is practically proportional to the differences between the wet and dry bulb temperatures of the air. As air is forced through hay in the mow, moisture is vaporized and is carried away by the air flow. Evaporation of moisture under such conditions is substantially the same as evaporation of moisture from a wet surface. During the major portion of the drying process, rate of internal diffusion of moisture within the hay is not a controlling factor, and the rate of drying is at an approximately constant rate as long as drying conditions remain constant. The heat necessary for moisture vaporization is supplied by the air, and consequently a drop in tem-







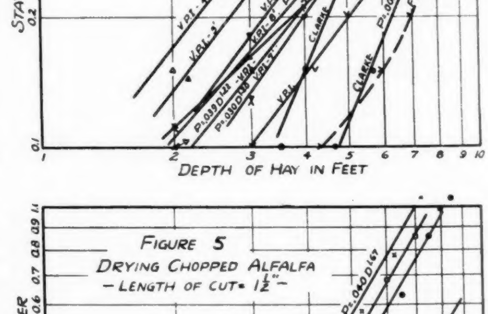


Fig. 2 *(Upper left)* Logarithmic graph showing typical pressure-volume relation in flow of air through alfalfa hay • Fig. 3 *(Lower left)* Logarithmic graph showing pressure-volume relation of air flow through eight different lots of hay both before and after drying • Fig. 4 *(Upper right)* Graph showing pressure-depth relation for tests of several barn hay driers. Each graphline is for a fixed rate of air flow • Fig. 5 *(Lower right)* Graph showing pressure-depth relation for air flow through chopped alfalfa hay. Alfalfa harvested in the prebloom stage. Nominal length of cut, 1½ in

perature must occur as air passes through the hay if drying is effected. When heat is generated within the hay mass, as is the case with tough hay, this heat aids in the removal of moisture from the hay.

Static Pressure Drop in Relation to Velocity of Air Flow Through Hay. Rate of evaporation of moisture from hay in the mow (within the time limits usually encountered in mow drying) is practically proportional to the velocity of air flow through the hay. The laws governing air flow are not so well known that results can always be predicted with accuracy. Fundamental laws of flow are recognized, but results are so affected by conditions under which flow occurs that it is usually necessary to obtain experimental data for reliable engineering calculations.

It is an engineering principle that under ideal conditions of low velocity, small ducts, and viscous or streamline flow, the pressure drop in air flow is directly proportional to the velocity of flow. Also, for high velocities and consequent turbulent flow encountered, the pressure drop is proportional to some power of the velocity higher than that applicable to viscous flow.

Since the velocities of flow, and the channels of flow through hay, are both relatively small, it is possible in view of the above that the pressure drop through hay may have some value somewhat less than that which would result if pressure drop were proportional to the square of the velocity of flow as is commonly assumed.

Numerous tests and observations of pressure drop through hay corresponding to various rates of air flow have shown rather consistent results in respect to pressure-velocity relationship. These experimental tests have been made under conditions where results were fairly accurately determined. Typical results are shown by Fig. 2 where

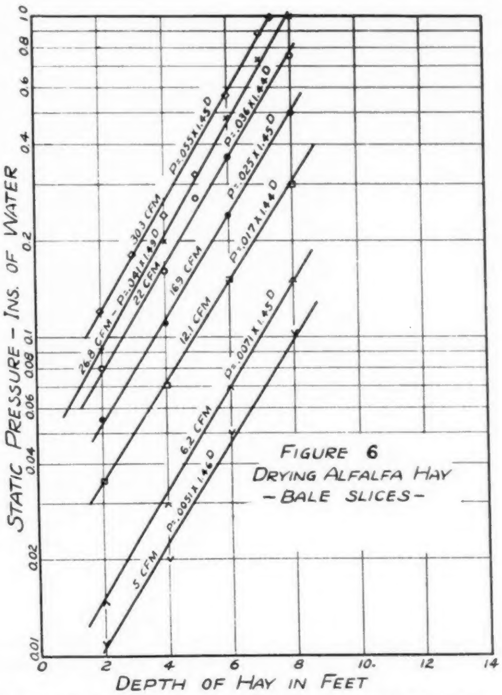


Fig. 6 A semilogarithmic graph of pressure-depth relation as observed in a number of tests of different lots of hay

volume of air flow per square foot of floor area is plotted against pressure drop. The plotted points will be seen to conform closely to straight lines. As these graphs are on logarithmic paper, the relation between air volume and pressure may be expressed by equations of the form

$$V = CP^{n}$$

where V is velocity of air flow in fpm (cfm per square foot of floor)

C is a coefficient which is constant for given conditions

P is the static pressure in inches of water

n is a power exponent which is constant for given conditions.

The value of the coefficient C as determined from these test data varied within a considerable range. For most conditions of our tests, where hay depths were comparable with actual field practices in drying hay in the mow the value of C ranged from 25 to 45. This range of values for C included tests with hay depths (before settling) between 8 and 12 ft.

In the test of air flow through chopped hay the coefficient C had somewhat lower values. With maximum depth of chopped alfalfa hay (prebloom stage) of 9 ft, the value of C for only one lot of hay ranged from 16 to 11 as the hay dried and settled.

The value of the exponent, n, which is indicated by the slope of line on the logarithmic graph, was rather consistent. Values throughout the entire series of tests ranged from 0.60 to 0.78, with few exceptions. The mean value of n for the several tests listed in Table 1 was 0.71. It might then be assumed that, for engineering calculations, the pressure drop through a well-planned hay drying system could be fairly closely approximated by assuming that it is proportional to the three-halves power of the velocity, or

$$V = CP^{2/3}$$

TABLE 1. APPROXIMATE RELATIONS BETWEEN PRESSURE DROP AND RATE OF AIR FLOW FOR EXPERIMENTAL AND FIELD TESTS

Source and test number	Type of hay	Date	Approx. depth, ft	Weight lb per sq ft	Moisture content, per cent	Values of C and n in $Q = CPn$: C	n
USDA-VPI	Alfalfa	9-15-44	12		51	30	0.71
Test 1-44	Alfalfa	9-27-44	8½		25	30	0.67
USDA-VPI	Peanuts	10-11-44	12		Vines-74½ Nuts-68	36	0.73
Test 2-44	as dug	10-20-44	9		Vines-21 Nuts-13	40	0.70
USDA-VPI	Alfalfa, 51%	5-19-45	8	62.5	60.7	30	0.65
Test 1-45	Grass, 29% Weeds, 21%	6-7-45	Settled to 6	30.3		22½	0.66
USDA-VPI	Alfalfa,	7-11-45	10	65.8	48	32	0.67
Test 3-45	½ bloom ½ pod	7-25-45	7½	43.2	20.8	28	0.69
USDA-VPI	Alfalfa,	8-29-45	8	57.7	43.2	27	0.69
Test 5-45	bale slices	9-4-45	6½	39.2	22.1	28½	0.67
USDA-VPI	Alfalfa,	10-15-45	9	84.5	40.8	16	0.76
Test 6-45	prebloom stage, 1½ in cut	11-7-45	7	60.8	17.6	11	0.78
USDA-Iowa	Alfalfa, ¾;	6-20-45	8 1/6			43	0.79
Lot No. 1	Brome grass, ¼	6-28-45	7			34	0.67
USDA-Iowa	Alfalfa,	8-14-45	8 1/6			35	0.76
Lot No. 2	approx. 96 per cent	8-22-45	7¾			34	0.77

The uniformity of results obtained in regard to pressure drop as related to rate of air flow is well indicated by the graphs of Fig. 3. Each line in Fig. 3 graphically shows the data for a given test condition. A graph line is shown for each lot of hay both before drying and at the end of the drying period.

In design calculations, if the pressure drop through hay should be assumed to be proportional to the square of the velocity, a factor of safety will be introduced. Such practice would necessarily involve higher equipment and operating costs than would be the case if the relation between air flow and pressure drop is as has been indicated by these experimental results. Further studies under more varied conditions should be made either to verify or disprove the above relation before it is generally accepted as reliable for engineering calculations for drying various hay and forage materials.

Pressure Drop and Depth of Hay. The results obtained in regard to pressure drop as related to depth of hay were not consistent. For any one lot of hay in the entire series of tests, the results obtained would seem to justify definite conclusions regarding pressure-depth relationship. However, the relationship varied from lot to lot of hay to such an extent that no general conclusions were drawn.

Numerous readings relative to pressure and hay depth were made under both laboratory and field conditions. Pressure drop and hay depth relationships are summarized in Table 2. The numerical values shown in this table are only approximate mean values for the tests. About three-fourths of the tests showed a pressure drop proportional to some power of the depth, the value ranging from 0.91 to 2.3, and about one-fourth of the tests showed an exponential relationship between pressure drop and depth of hay.

Examination of the data in Table 2 and source material discloses that, when long loose alfalfa hay only is considered, the pressure drop was proportional to some power of the hay depth, with the value of the power ranging from a minimum of 0.91 to a maximum of 1.3 for our tests. Only one exception was noted, thus indicating that, in general, for a given rate of air flow the rate of pressure increase was slightly greater than the rate of increase in depth.

TABLE 2. APPROXIMATE RELATION BETWEEN PRESSURE AND DEPTH FOR VARIOUS EXPERIMENTAL TESTS

Test		Equation (approx.)	Approx. depth of hay, ft	Remarks
1-44		$P=K\times1.32^D$	12 to 9	Data obtained by probing Alfalfa-long hay
2-44		$P=K\times1.34^D$	12 to 9	Data obtained by probing Peanuts—vines and nuts
1-45		$P=CD^{.97}$	8	Alfalfa—grass—weeds. Data obtained as drier was loaded
3-45		$P=CD^{1.11}$ to $P=CD^{1.22}$	10 to 7½	Data obtained as drier was loaded and later by probing—long alfalfa
5-45		$P=K\times1.44^D$	8 to 6½	Alfalfa bale slices Data by probing
6-45		$P=K\times1.14^D$ $P=CD^{1.67}$	10 7	Alfalfa, chopped 1½ in long. From data obtained as drier was loaded, probed
Field tests	(1)*	$P=CD^{.91}$	8	Long alfalfa
	(1)	$P=CD^{1.09}$	8	Long alfalfa
	(6)	$P=CD^{1.20}$	7	Long alfalfa
	(6)	$P=CD^{1.30}$	6	Long alfalfa
	(2)	$P=CD^{2.30}$	9	Chopped alfalfa and lespedeza
TVA tests	(1)	$P=CD^{1.04}$	9	Alfalfa
	(2)	$P=CD^{1.66}$	9	Lespedeza
	(1)	$P=CD^{1.88}$	12	Alfalfa
W-tests	(1)	$P=CD^{.87}$	10½	Clover, chopped
	(1)	$P=CD^{2.43}$	13	Alfalfa, chopped
	(1)	$P=CD^{1.0}$	7	Alfalfa, chopped
L-tests		$P=K\times2.0^D$ to $P=K\times2.4^D$	7	Air pressures to 2 in Velocity to 50 fpm

*Numbers in parenthesis denote number of tests.

In Figs. 4, 5, and 6 are shown graphs of typical pressure-depth relationships as disclosed by these studies. Fig. 4 shows several graphs on logarithmic paper, of data obtained by field tests. When the data of any one test lie on a straight line, on a logarithmic graph, the relation between the two variables may be expressed by an equation of the form

$$P = CD^n$$

where P is the static pressure in inches of water
D is the depth of the hay in feet
C and n are constants for given conditions of tests.

When the value of the power exponent, n, is unity in such an equation, the line also graphs as a straight line on arithmetic paper. This condition indicates a true straight line relationship between pressure drop and hay depth, and the drop in pressure would in such cases be directly proportional to depth of hay. Although some variation in the value of n could be attributed to experimental error, the rather wide variation observed, mostly in the range above unity, indicates that the variations shown cannot thus be accounted for. No particular difference in variation was observed between data obtained under laboratory conditions and those obtained from field tests. Data from sources other than our own tests gave results varying in the same manner and to an equal or greater extent, as may be noted from the last eight equations in Table 2.

Fig. 5 is a logarithmic graph of data pertaining to pressure drop and hay depth as obtained during one series of tests of chopped alfalfa hay. Pressure data were obtained as hay was loaded into the bin, and also later by probing into the hay mass. This figure indicates the uniformity of results under given conditions. Although the value of n varied considerably from one lot of hay to another, it remained within rather narrow limits for any one lot.

As previously mentioned, data obtained by some of the tests of different lots of hay did not conform to the relationship expressed by the above power equation. When the data were plotted, the points did not indicate a straight line graph on either arithmetic or logarithmic paper. However, when the data were plotted on semilogarithmic paper, as shown in Fig. 6, straight line graphs resulted. The relationship between pressure drop and hay depth in such instances may be expressed by an equation of the form

$$P = KA^D$$

where P and D have the same meaning as previously given
K and A are constants for given conditions of test.

In this expression for the relationship between pressure drop and hay depth, it is apparent that the pressure required to effect a given rate of air flow will be greatly increased for the greater depths of hay. Fortunately hay driers have in general been operated (in the Southeast at least) under conditions of hay depth such that the pressure requirements for reasonably satisfactory drying have not been prohibitive. Hay depths at one drying have not customarily exceeded about 10 ft. The rate of pressure increase under the conditions noted above does not appear usually to change greatly before the depth of hay reaches 6 to 10 ft. This exponential relation might explain, in part, the reason for certain instances of hay drying difficulties which have otherwise had no evident explanation. Why such an exponential relationship between pressure gradient and hay depth should exist, if it does, is as yet not known. More extensive studies should either verify or disprove this indicated exponential relationship.

SUMMARY

Perhaps it would be well at this point to stress again that any conclusions to be drawn from this series of tests can be only tentative. It may be that further studies will show that these inferences are in error, or that the numerical values indicated must be altered to meet various conditions encountered. In engineering calculations for the design of hay driers — as for other similar situations — it will be desirable to adhere to recognized and established relationships and principles when available. In the absence of satisfactory information suitable for design purposes it will be necessary to utilize such information as is available. Further studies are definitely indicated in order to establish reliable and general rules for resistance of hay to the flow of air.

The Distribution of Air Through Chopped Hay

By F. W. Duffee

FELLOW A.S.A.E.

THIS paper deals with the problems of getting air through chopped hay only, and includes the experiences of a considerable number of men with whom we have worked during the past season in Wisconsin.

The first installation made in 1945 was designed according to recommendations of the Tennessee Valley Authority and we did not at that time appreciate that chopped hay would be quite different in its behavior than long hay. We had had a limited amount of experience in 1944, using the standard TVA design with chopped hay, but there was something about the way that was handled, together with the fact that slightly heated air was used, that was apparently different than observed in 1945.

The system was designed for 10 cfm per sq ft of mow floor at ¾-in static pressure. Using a forward curve centrifugal fan (American Blower 121), 6 to 8 ft of hay was placed in the mow, and it was assumed that the fan would have to be throttled somewhat with this amount of hay in place.

To our surprise, we found the static pressure in the main duct varied from 1⅛ to 1¼ in. The fan was operated at about 530 rpm.

The following data taken from the company's catalog, indicates approximately what happened to the volume of air; the closest comparable figure for speed is used:

507 rpm—¾-in static pressure—10,300 cfm delivered.

512 rpm—1-in static pressure—5,140 cfm delivered.

Data is not available for 1⅛-in static pressure and a comparable speed. Even so the volume of air delivered at 1-in static pressure would have been slightly less than half of what was anticipated, and at the still higher pressure which actually existed, the volume would be still less. We have assumed not over about 40 per cent of the anticipated volume.

This paper was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946.

F. W. DUFFEE is chairman, agricultural engineering department, University of Wisconsin.

NOTE: The author wishes to acknowledge the assistance of the following persons who cooperated with him during the season of 1945: G. L. Larson, chairman, mechanical engineering dept., and H. D. Bruhn, agricultural engineering dept., University of Wisconsin; C. E. Frudden, Allis-Chalmers Mfg. Co.; M. W. Bishop, American Blower Corp., and Ralph Walter, Wisconsin Power & Light Co.

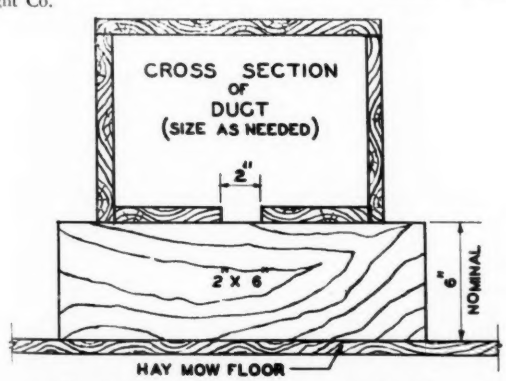


Fig. 1 Lateral duct design for a mow hay drier

The next farm observed had a propeller-type installation. This also was designed to deliver 10 cfm per sq ft at ¾-in static pressure. At the time we first visited the installation, the hay varied from 2 to 3 ft deep up to about 8 ft deep.

The discharge of air through the hay was measured with a funnel and anemometer. The anemometer was placed in the small end, and the large end was ten times as large as the opening through the anemometer; thus readings were multiplied 10 to 1. Subsequent checking of this equipment indicated it was reasonably accurate.

The surprising thing was that the delivery of air through the hay was about the same where the hay was shallow as where it was deep, and in all cases the delivery was for the most part around 2 or 3 cfm per sq ft.

Our first assumptions were that this was due to the high resistance of chopped hay, or that the hay was extremely wet when placed in the mow. In any event, we were not sure what the trouble was, but there surely was serious trouble.

At still another place, we found essentially the same condition, that is, high static pressure in the main and low discharge of air through the hay.

A ¼-in pipe probe was made with a twist drill welded into the end for insertion into the hay, and for drilling through the top of the lateral into the lateral duct. Small holes were drilled through the side of the pipe, just above the end of the drill, for the purpose of measuring static pressure.

Data secured with the use of the probe indicated a high drop in pressure from the lateral to the hay directly on the outside of the lateral.

With the conventional TVA duct design, it seems as though, when long hay is spread over the system, it probably drapes over the duct in such a way as to leave the air vent at the bottom of the lateral completely free or uncovered, and in addition there is probably some additional air space between the hay and the sides of the lateral, particularly at the bottom of the duct. A. W. Clyde of Pennsylvania State College, I find, is of the same opinion, while John A. Schaller of TVA says it lies a little bit more on top.

Chopped hay, on the other hand, falls directly down along the sides of the duct and plugs the vent. Further, if the system is operated for a considerable period of time, dust will enter it and plaster the hay at the duct vent and thus further increase the resistance to the flow of air from the duct system.

In another case, using an engine-driven fan and a duct system of the conventional TVA design, the following data were obtained: With the hay about 20 ft deep, we found a static pressure of 2.25 in in the main—2.2 in in the lateral and 0.7 in in the hay just outside the lateral. Of course, we are never sure as to just how far we are from the lateral due to the fact that the probe may not go straight down; however, in all cases we were probably within 1 or 1½ ft.

Thus there was a drop in pressure of 0.05 in from main to lateral, and a drop of 1½ in in static pressure from inside the lateral to the hay outside.

We should keep clearly in mind that it is static pressure and static pressure only that moves air through the hay, and static pressure is one of the important factors in determining power required to operate the system. In this particular case, the fan was building up a *(Continued on page 215)*

Problems in Handling Damp Hay

By R. C. Shipman
MEMBER A.S.A.E.

THE purpose of this paper is to present some of the ideas, methods, and procedures used and problems encountered by Indiana farmers this past season in handling hay placed on mow hay-curing systems. There were 30 hay-curing systems in operation in the state during the 1945 season. Five of the systems had been used the previous season and one had three years' experience.

The over-all problem of handling damp hay according to the operators is essentially the same as handling field-cured hay, that is, developing a quick, easy method of moving the hay from field to storage. For this reason there is great interest in the pickup field chopper as a method of handling hay. It is interesting to note that fifteen of the curing systems handled chopped hay, eleven handled long hay, and four used bales. This was essentially the same form the hay had been stored in the years previous to use of the curing systems.

Regardless of the method used for handling the hay, one of the most serious problems was to know the moisture content of from 30 to 40 per cent. They were all at a loss to know how to gauge the dryness of the hay, and as a result there was a tendency to place the hay in the barn at moisture contents of from 40 to 50 per cent. Even with the use of moisture-determining equipment, one of the problems was securing a representative sample from the windrow in the field to obtain the moisture reading. It was quite common to have farmers take samples in the field for moisture determination and one hour later, as the hay was sampled from the mow, to find the moisture readings in the mow 5 to 8 per cent higher than those taken in the field.

These inaccuracies are not in the moisture-determining equipment but in the method of taking samples in actual practice on the farm. This suggests that the development of a moisture-determining procedure for practical farm use under field conditions would take much of the guesswork out of making hay.

Those farms handling long hay and baled hay at 30 to 45 per cent moisture reported that the damp hay was no harder to handle than the dry hay they had been handling in the past. Observations indicated that when the total moisture content of the hay ran between 35 and 40 per cent moisture, there was less shattering of leaves providing the hay was windrowed in the field. In three cases where the hay was cured in the swath, severe shattering of leaves occurred even with a total moisture content of 40 per cent due to the large amount of moisture in the stems. This emphasizes the importance of windrowing for uniform curing and prevention of leaf loss.

All but one of those farms handling long hay used the wagon, loader, and grapple fork to place the hay in the mow. One farmer used the auto buck rake to transport the hay from the field to the barn. At the barn a blower constructed from the straw blower of a grain thresher was used to place the hay in the mow. The hay was pitched by hand into the blower at the ground level. The hood on the blower pipe was used to distribute the hay uniformly over the curing system. This method has been used for two seasons with good results. There is very little separation of the leaves from the stems of high-moisture hay. However, this same blower used on dry hay caused considerable breakage of stems and shattering of leaves.

The handling of baled damp hay, although limited to only four cases, differed very little from the customary baling procedure. Three twine balers and one wire baler were used. All operated satisfactorily on 35 to 40 per cent moisture hay with proper adjustments of bale compression and feeding mechanism without undue strain on the baler. It was possible to make a heavier and more tightly compressed bale with the damp hay, the average weight of the 42-in length bales ranging 85 to 90 lb. Bales as heavy as 125 to 150 lb could be made but were too difficult to handle. The 85 to 90-lb bales weighed about 60 lb when cured. This density of bale weighed approximately 9 lb per cu ft, or about 225 cu ft of tightly packed bales equaled 1 ton of hay at 10 to 12 per cent moisture.

The actual process of handling the bales from the field to the barn was simplified in two cases. To eliminate the extra operation of gathering bales in the field, a chute was placed on the baler to load the bales on a trailer wagon. One man on the wagon loaded the bales. The common practice is to use a bale hook to assist in handling these 75 to 100-lb bales. The bale hook on the wagon is dangerous. Two cases were reported where the man loading the bales on the wagon had been hit by the sharp point of the hook as it slipped from the bale.

To eliminate the need of the bale hook with one baling unit, the baler was set to make a short 27-in bale. This bale weighed around 55 lb and could be handled easily. As the crews became accustomed to the small bale, they found it could be handled all day with less fatigue than the heavier bale. As high as 300 bales per hour of this size were loaded by one man on the wagon. In one case 15 tons of hay were baled and placed in a ground-level curing system by a 5-man crew in two hours' time.

Many types of elevators were used to place the bales in barns and stacks, ranging from the portable ear corn elevators to many types of home-built elevators. One desirable feature of one type of home-built elevator is that it is constructed with a single chain conveyor, with the flights placed about 12 ft apart. This has the advantage of making it possible for the person unloading to place the bales flat on the elevator between flights and also prevents the possibility of overloading the elevator. A good low-cost, lightweight, portable bale elevator would be welcomed by farmers handling baled hay.

The handling of hay by the pickup chopper has created the most farmer interest, because it offers the possibility of moving the hay from the field and placing it in the storage with the least physical effort. This past year's experience with choppers indicates that as long a length cut of hay as possible is desirable from the standpoint of quality of hay. The shorter cuts cause more damage to the leaves. Three to 4-in actual lengths of cuts are desirable, and possibly 6 to 10-in might be more satisfactory if it can be obtained in a practical way. The main purpose of chopping is to facilitate handling of the hay with conveyors or blowers much in the same manner as ear corn or small grain.

Of the 15 systems handling chopped hay, ten used the pickup chopper. Various types of wagons were used to

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This paper was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946.

R. C. SHIPMAN was formerly extension agricultural engineer, Purdue University, and is now associate agricultural engineer, research and development division, Cooperative G.L.F. Farm Supplies, Inc.

transport the hay from the field to the blower at the barn. Three types of unloading devices were used in the wagons. One type consisted of a movable endgate set in the front of the wagon rack. To this endgate was attached two cables which extended to the rear of the rack and fasten to a pipe which serves as a drum to pull the entire load of hay out of the back of the rack into the blower feed table. In one case a ½-hp electric motor with a suitable speed reduction was used to power the windlass.

Another method used was to place a special heavy canvas in the bottom of the rack, and winding this canvas around a roller to move the entire load out of the rear of the rack. Still another method was used in which a modified manure-spreader web was placed in the bottom of the rack. The results of the three types were about the same; however, the cost of the movable endgate unit was the lowest of the three. The canvas was relatively short-lived because of the wear caused by sliding on the bottom of the wagon bed.

The main difficulty encountered with the stationary choppers was to obtain a sufficient length of cut as most of the choppers had been designed for ensilage and short cuts of roughage. Also considerable difficulty was experienced in securing an even distribution of hay in the mow because of lack of blower capacity. The stationary chopper method of placing the hay in the mow has the disadvantage in that the long hay has to be handled from the field to the chopper. In one case the buck rake was used to haul the hay from the field, but this farmer is planning on eliminating the buck rake as soon as he can secure a pickup field chopper.

Fairly good results were secured with the blowers to handle chopped hay but there still remains a lot of room for development. Blowers that work satisfactorily on dry chopped hay and green ensilage oftentimes have limited capacity on the partially cured hay. Experiences indicate that larger blower pipes would be more effective in handling partially cured chopped hay.

Distribution of the hay in the mow has been one problem. It has been very easy to set up the blower pipe and let the hay pile up. The usual practice has been to place a man at the blower discharge to spread hay uniformly over the mow. Due to the severe action of the blower on the hay there is some fine dust and separation of leaves even with high-moisture hay, and this may be one cause of stratification of the chopped hay in the mow as it is placed in layers.

We have very successfully used the idea of building up the full depth chopped hay at one end of the barn and working toward the other end with this depth of 6 or 8 ft of hay to eliminate stratification. This can only be done with a system designed so that the main air tunnel can be entered to close any laterals not being covered by hay. We have also found that it is important to turn the air into any laterals before chopped hay is placed over them. This removes any fine dust or leaves that tend to seal the openings from the laterals and restrict the flow of air.

The common blower used to handle chopped hay causes considerable mechanical damage to the chopped hay. The possibility of a carrier or conveyor would eliminate this difficulty and would be very desirable if one could be constructed that would accomplish distribution in the mow and still be comparable in cost to the blower. It should be light in weight, easy to set up, and flexible in use in various types of structures.

There is much room for development work in equipment to handle hay whether it be damp hay or field-cured hay. Important phases that should not be overlooked is the connecting link between the equipment in the field and the equipment used to place the hay in the barn.

Distribution of Air Through Chopped Hay

(Continued from page 213)

high pressure, thus requiring considerable power, but this pressure was lost before it reached the hay, so that only a relatively small amount of pressure was available for forcing the air through the hay.

In several other cases we found the pressure drop from the lateral to the hay as being about 0.4 in.

We started out with an assumed pressure in the main of ¾ in; actually it was higher. About half of this total pressure is used to move the air just a few inches from the inside to the outside of the lateral.

To allow for a freer flow of air from the lateral duct to the hay, a new design (Fig. 1) was developed for the lateral. This lateral is structurally substantial, and is not affected appreciably by uneven floors. Also, there is very little turbulence inside of it.

This lateral showed a drop in pressure of from 0.02 to 0.04 in between the lateral and the hay, with a discharge of air of about 10 cfm per sq ft.

Again I want to emphasize the fact that it is static pressure which moves the air through the hay. We have limited power, and therefore I believe we must design a duct system all the way through that will deliver the air from the fan to the hay with a minimum loss of pressure. In other words, we should use as little of the power as possible in the duct system, so as to have as much power as possible to deliver the air through the hay.

A word about the drop in pressure from the main to the lateral. With the conventional duct system, and using chopped hay, a greatly reduced volume of air moved through the system, and the pressure drop from the main to lateral was small. However, with the new lateral duct which allowed for a freer discharge of air from the lateral to the hay, consequently larger volumes of air moved through the system, and drop in pressure from the main to lateral was increased in the order of 0.17 to 0.23 in static pressure with air volumes to 10 to 13 cfm per sq ft. The sizes of the lateral ducts were determined from the TVA handbook.

We are of the opinion, therefore, that the junction of the lateral to the main should be redesigned so as to reduce the velocity and thus reduce friction losses at this point.

It was found that in most cases 40 to 100 per cent of the total air delivered by the fan was lost through the sides of the mow when the depth of hay exceeded 8 or 10 ft. H. D. Bruhn, research agricultural engineer, University of Wisconsin, has suggested the desirability of using a high (4 to 6 ft) center main duct with a conventional arrangement of laterals. The system so arranged that, when hay covers the main by 3 or 4 ft, the laterals can be closed and doors near the top of the main opened.

In one case where the new lateral duct design was used and where hay was 13 ft deep, there was no air coming through the top of the hay except for one very small area. The fan apparently was delivering 10 cfm per sq ft of floor area, but examination revealed that practically all of the air was escaping through the cracks in the barn walls.

Chopped hay blown into the mow apparently becomes stratified and this condition appears to aggravate the condition of air escaping into the sides of the mow rather than moving upward through the hay.

Experience the past season indicates that the length of cut is an important factor in establishing resistance to the flow of air through the hay, and we know from experience that the length of cut is important in determining palatability of chopped hay. Therefore, we have gone so far at the present time as to advise farmers not to buy any forage

harvester unless the manufacturer will guarantee it to successfully operate with a theoretical 2-in cut. This will mean that the hay will average about 4 in in length.

By theoretical length of cut, we refer to the advance of the feed mechanism for each cut of the cutterhead. Due to the fact that hay passes through the cutterhead more or less crosswise, the average actual length of cut will be about twice the theoretical length of cut.

In order to determine the drop in pressure through the hay, a 14-ft silo was fitted with a plenum chamber in the bottom, and a slat floor consisting of 2x4's spaced 1⅝ in. Chopped hay (2-in cut) was filled to a total depth of 10½ ft (three fillings). The drop in pressure through this chopped hay was about 0.06 in per ft of depth, with an air flow of 11.8 cfm per sq ft of floor area.

In conclusion, the first thing which we consider of primary importance is to deliver air from the fan to the hay with a minimum loss of power. Secondly, we must know the friction loss through the hay before we can intelligently design a system. This friction loss is probably affected by the maturity and texture of the crop, and density as affected by depth of storage and the length of cut.

"Professional Agricultural Engineering Service for Farmers"

TO THE EDITOR:

THE letter from Carl R. Olson in AGRICULTURAL ENGINEERING for February raises an interesting question, one to which I have given some thought in recent years. How can a professional agricultural engineer make a living by selling his services to rural communities?

I have spent nearly forty years, first with the government and now with a state university, in research work in drainage, conservation and soils. During this time I have done a large part of the extension work in drainage and some in the other two fields. Although I may at times have been guilty of encroaching on the field of the private engineer by giving advice in drainage, soil conservation and land appraisals, which could just as well have been done by an engineer in private practice, I have, in the vast majority of cases, confined my advice to an explanation of the fundamental principles involved and advised my would-be clients to seek the assistance of a private engineer for the details and the final plans and installation.

I am sure that this has very largely been the attitude of the Agricultural Extension Service, at least as it operates in this state, but it has not been the attitude of some of the federal agencies. A big talking point of one federal bureau has been that their advice and assistance is *free*, and this agency has freely criticised the University for having been negligent in not meeting the farmers' needs in greater detail and in not providing more personal service.

It is my opinion that the state college can be very useful both to the farmer and the private engineer in pointing out the latest developments in any field, as shown by research, but when it has gotten the farmer to the point of wanting a drainage system, an eroded field protected, a building erected, or some other improvement made, the job should be turned over to a private engineer to work out the details and to complete the work.

I fully agree with Mr. Olson when he says, "I am fully aware of the benefits and necessity of erosion control, but I am not so convinced of the need for an everexpanding government organization to perform all of the functions of the program. . ."

I have long believed that the fundamental purpose of the university and the U. S. Department of Agriculture is one of research and education, and when the government or the state obtains the facts, through research, and carries the information to the field, to the point where the farmer knows what he wants and how to get it, the agency has performed its duty. From that point on the farmer should use his own initiative, and if the job is beyond his personal ability, he should hire someone professionally trained to carry on and he should pay something for this service.

It is only by paying for it — and I do not mean at exorbitant prices — that the recipient appreciates advice. Those things we get for nothing are usually valued at about what they cost.

It is obvious to me, and it must be to many A.S.A.E. members, that we are swiftly drifting into a get-something-for-nothing or a let-the-government-do-it attitude. Of course, one of the deepest pitfalls lies in the assumption that we are actually getting something-for-nothing from the federal government. These same engineers, who are being deprived of a livelihood by government-financed action programs, are actually paying the bill through everincreasing federal appropriations and unbalanced budgets.

One cannot expect the federal government to provide all this free service and not expect something in return. Soil conservation district, TVA's, reclamation service projects, and others like them are depriving not only the farmer and the engineers, but also the whole nation of its free thinking and pushing us into socialized thinking and doing.

There is a definite place for agricultural experiment stations, agricultural extension services, and many of the federal research agencies. There is no limit to the new ideas and improved methods that can come from these activities, and they should have better financial support than at present, but these agencies, state and federal alike, should confine their efforts to research and education.

WALTER W. WEIR

TO THE EDITOR:

I HAVE just read Carl R. Olson's letter in AGRICULTURAL ENGINEERING for February. He discusses a situation that offers much opportunity for agricultural engineers. Personally, I do not see much difference between employment of an engineer by the state to do certain services and employment by an industrial organization to perform similar service for its customers, at least as far as the individual himself is concerned. In either case the engineer has an employer who is hiring him to exploit his services because he finds it profitable and necessary to do so. However, there is no reason why the engineer himself should not perform these services as an agent, and I am sure that if he did so, he would find his engineering to be more interesting because it is independent and not limited by the employer.

I believe the principal reason why agricultural engineers have not developed independent engineering services is largely because there have not been enough agricultural engineers to supply the demands of industry and government and consequently there has been little necessity to use one's imagination or ingenuity in obtaining employment.

In regard to the field for independent agricultural engineering services, it is wide open, and there is no limit to the opportunities for its development. There are certainly numerous opportunities in farm structures, soil and water conservation and control, and mechanical and electrical equipment services. However, just because the opportunities exist does not mean they will be developed. As I have indicated, the development is more likely to wait until there are more agricultural engineers available and few employers for their services, in which case they will begin to expand and develop independent professional service organizations.

GEORGE R. SHIER

Air Flow in the Main Duct of a Barn Hay-Drying System

By G. W. Steinbruegge

IN BARN hay-drying systems air is delivered from a fan to a main duct and thence through lateral ducts or other means of distribution to the hay to be dried. The fans are capable of delivering sufficient air for the system at only moderate pressures (usually static pressures of 1 in of water or less). Losses of pressure due to friction or leakage are to be avoided wherever possible to secure maximum delivery with the smallest expenditure of energy.

Of first concern to the agricultural engineer after the installation of a barn hay-drying system are the answers to the following questions: Is as much air getting through the system as was expected? Is the back pressure at the fan equal to that on which the design was based? That the answers to those questions have given many engineers considerable trouble is evident from the discussions which took place at the A.S.A.E.-sponsored barn hay-curing conference at Purdue University in January. The answers to the above questions can be determined with fair accuracy by means of pitot-static tube readings if the testing engineer understands the use and limitations of the pitot-static tube.

A pitot-static tube is a commonly used device for measuring the total pressure and static pressure of flowing air. The differential of the total and static pressures is the impact pressure due to the velocity of the flowing air. This differential pressure when measured in inches of water by a suitable manometer and substituted in the formula $V = 4000\sqrt{h}$, where h is the vertical difference of the fluid levels of the manometer, gives the air velocity in feet per minute (fpm). With the velocity thus determined, the volume delivered in cubic feet per minute (cfm) is obtained by multiplying this velocity by the cross-sectional area (sq ft).

The design of the pitot-static tube is important and a standard design such as that approved by the National Association of Fan Manufacturers should be used. Whether the instrument has a sharp nose such as shown in Fig. 1, or whether it has a round nose, seems to have little effect upon the operation of the tube provided other details are properly correlated with the design. The number and location of the static pressure holes is probably the most important detail of the pitot-static tube design and should be adhered to closely.

Of the two pressures measured in flowing air, static and total, the true static pressure is by far the more difficult to obtain. If conditions of turbulence and unsteady flow are present, as in barn hay-drying ducts, the static pressure readings are thoroughly unreliable and of no value. For this reason it is necessary to take precautions which insure reasonably streamlined flow for securing static pressure readings. Using a section of the barn duct to straighten out the flow (as illustrated in the example below) is a good method for obtaining fairly uniform and non-turbulent air flow in which to run a pitot-static tube traverse.

If the pitot-static tube is slightly askew with the direction of air flow as shown in Fig. 1, both the total and static pressures as measured will be less than the true pressures. However, the error in the total pressure reading is negligible up to angles of about 20 deg with the true direction of air flow. On the other hand, this is not true of the static pressure readings which may be considerably erroneous even at small angles of yaw.

Professor M. M. Jones, of the University of Missouri, and the author have obtained data on the air flow in the main duct of a representative hay-drying installation, as outlined below.

A barn near the University having a hay-drying system installed in the 30x80-ft loft and using a 23,000-cfm centrifugal blower driven by a 7½-hp motor had hay being dried only on the half of the duct system farthest from the fan. The lateral ducts nearest the fan were closed by boards nailed across the lateral openings into the main duct. The fan was operating at a speed of 555 rpm and drawing approximately 5.3 hp from the driving motor. The average of eight static pressure readings taken with a pitot-static tube in the main duct directly in front of the fan opening indicated that the static pressure head was 0.52 in of water. Velocity pressure readings taken at the same time indicated an average velocity of 3670 fpm across the fan opening of which the area was 8.6 sq ft. Calculation shows then that the volume should be 31,500 cfm. Reference to the fan catalog tables shows that this fan drawing 5.3 hp and operating against a static pressure of 0.52 in of water should be delivering 21,000 cfm when running 447 rpm. However, the speed of the

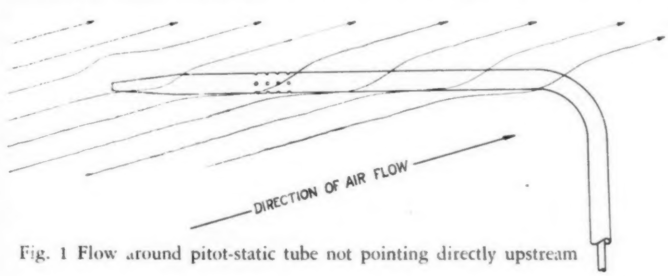

Fig. 1 Flow around pitot-static tube not pointing directly upstream

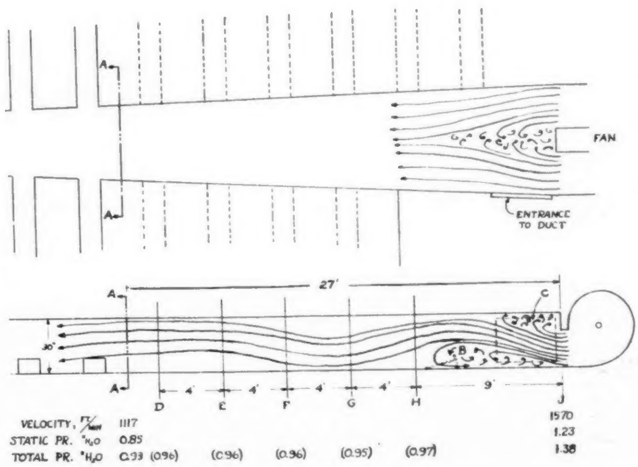

Fig. 2 Layout of main duct showing type of flow and areas of extreme turbulence

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G. W. STEINBRUEGGE is a member of the agricultural engineering staff, University of Missouri.

fan was 555 rpm. This indicates immediately that the static pressure, as determined, was too low resulting in too great a differential pressure with a consequent abnormally high calculated velocity.

We next entered the duct while the fan was blowing and had no difficulty in finding that the air flow through the duct was as indicated in Fig. 2 and that there were some back currents at B and C with high turbulence in these areas. These determinations were made with a man lying prone upon the floor of the duct and facing upstream while exploring the areas in front of him with his hands. It is true that his body created additional disturbance in the air stream but the true air flow was still unmistakably as shown. A wooden laboratory ring stand, having a base 4x11 in, when placed at B was drawn rapidly toward the fan if the entrance door to the duct was opened.

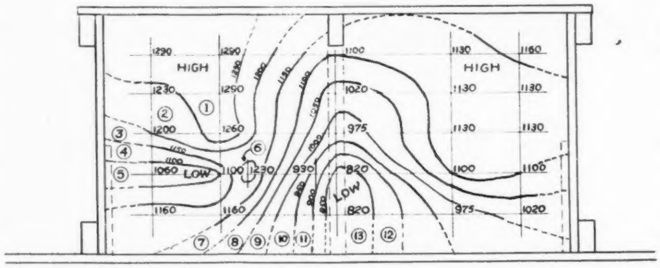

Fig. 3 Section A-A. Cross section of main duct 27 ft below fan. View looking downstream

A pitot-static tube traverse taken across the duct at the point indicated by the plane A-A in Fig. 2, showed the velocity to be quite variable across the duct but averaging 1117 fpm. The area of the duct at this point was 12.08 sq ft and the calculated delivery volume found to be 13,500 cfm. This was probably very close to the true figure inasmuch as the air was flowing reasonably straight down the duct though still in stratified layers of unequal velocity. The velocity was calculated from the data secured at section A-A as follows: A scale diagram was drawn as shown in Fig. 3 and the locations and magnitudes of the velocities plotted thereon. Velocity contours were then drawn in at 50-fpm intervals. The planimetered areas between successive contours were then found and multiplied by the mean velocity of the respective areas. The average of these weighted velocities was 1117-fpm. It should be mentioned that readings were taken at 27 points and that a simple average of these readings yielded 1110 fpm as the velocity. The close approximation of this simple average to the weighted mean is, however, pure coincidence inasmuch as such widely varying velocities were present. It should also be pointed out that, since the velocities do not bear a straight line relationship to the observed velocity pressures, the velocities should be computed before the average is taken rather than computing the average velocity pressure and determining the velocity from that average pressure. The quantity of air passing the plane A-A was 13,500 cfm. This was probably the best estimate of the output of the fan. There was insignificant leakage between the fan and the point A-A. The average static pressure at A-A was 0.85 in of water. The velocity pressure corresponding to 1117 fpm is 0.08 in of water. Therefore the weighted mean of the total pressures was 0.93 in of water. A set of total pressure readings taken at the points D, E, F, G and H shown in Fig. 2 (four readings were taken at each point and averaged)* showed that the total pressure was rather constant throughout this length of duct. Readings taken closer than 9 ft from the fan showed an average drop in total pressure which is an impossibility. These readings were therefore discarded.

The air flow at the fan opening (J) was found to be more uniform and less turbulent than the air flow between J and H. The average of 8 total pressure readings taken at J was 1.38 in of water. Since the volume delivered was 13,500 cfm and the fan opening was 8.6 sq ft, the average velocity at J must have been 1570 fpm. The corresponding velocity pressure is 0.15 in of water; therefore the static pressure at J was 1.23 in of water. This indicates a static pressure loss of 0.38 in of water between the fan and the section A-A. The bulk of this loss undoubtedly occurred in the turbulent region between J and H. References to the fan catalog tables indicate that this fan when running 555 rpm against a $1\frac{1}{4}$-in water static pressure would be delivering somewhat less than 13,500 cfm, but, nevertheless, the agreement is reasonable.

The above static pressure loss of 0.38 in of water was calculated from tests run with the system choked down to about 60 per cent of its full capacity. At 100 per cent capacity the turbulence would very likely not be decreased and the static pressure loss due to this turbulence at the duct entrance not be decreased either. It is evident to the author that streamlining in the section H-J would be very beneficial in this case.

At the hay-drying conference at Purdue University there was considerable discussion concerning back pressures at the fan. Some investigators indicated that they found pressures at the fan higher than they expected (up to 1 in static). Other investigators said they found pressures of no more than about $\frac{1}{2}$ in of water at the fan. In the light of this study the author feels that the static pressures at the fan are probably nearer the higher figure and the quantity of air flow consequently diminished than is normally suspected. Errors of measurement with pitot-static tubes tend to decrease the static pressure readings with an accompanying increase in the differential or velocity pressure readings. This makes it appear that the fan is operating at low pressure and large volume.

*AUTHOR'S NOTE: It is recognized that the total pressure readings taken at each point cannot properly be averaged. A weighted average would be proper, but this requires a determination of the static pressure at each point which would very likely be more erroneous than the above procedure. Furthermore, the readings as taken might be too low. The uniformity of the readings suggests that this is unlikely.

REFFERENCES

Aeronautical Research Committee, *Modern Developments in Fluid Dynamics*, vol. 1, 1938, Oxford.

Pannell, J. R. and Frazer, R. A., *The Measurement of Fluid Velocity and Pressure*, London, 1924.

Carrier, Willis Haviland, *Fan Engineering*, Buffalo Forge Co.

Bear, R. M., *Differential Pressures on a Pitot-Venturi and a Pitot-Static Nozzle over 360-degree Pitch and Yaw*. National Advisory Committee for Aeronautics. Report 264, 1927.

Museum Pieces

TODAY we are making the museum pieces for the museums of fifty years from now. And these pieces are going to look just as funny fifty years from now as the ones do today that are twenty-five or thirty years old.

So we don't come to any finality on these things. They are transient. This is just another day in the chain, another mile in the road; and so these museum pieces we are building today must always be looked at in terms of how they are going to be looked at fifty years from now.

Of course we have a lot of people come around and say, "What do you think the automobile of fifty years from now is going to look like?" I don't care. Let it look the way the people want it to look. Don't try to force it on them. — C. F. Kettering in "A.S.T.M. Bulletin", Dec., 1945.

Progress Report on Comparing the Efficiency of Three Methods of Harvesting and Preserving Forage Crops

By R. E. Hodgson, J. B. Shepherd, L. G. Schoenleber, H. M. Tysdal and W. H. Hosterman
MEMBER A.S.A.E.

THE forage harvesting research program at the USDA Agricultural Research Center at Beltsville, Md., is being conducted cooperatively by the Bureau of Dairy Industry, the Divisions of Agricultural Engineering and the Division of Forage Crops and Diseases of the Bureau of Plant Industry, Soils and Agricultural Engineering, and the Grain Branch of the Production and Marketing Administration. The program is planned to compare the relative efficiency of silage-making, barn-curing, and field-curing methods of harvesting and storing hay crops. It includes in each case a determination of (1) the losses of dry matter and feed nutrients during harvesting and storage, (2) changes in the chemical composition and in the carotene, color and leafiness of the forage, and (3) labor and machinery requirements for putting up the crop. Comparative feeding experiments are being conducted to determine for each roughage (1) the value for milk production, (2) the effect on the vitamin A content of milk and (3) the anti-ratchitic properties. Research is also being conducted to improve the practical efficiency of the methods used in silage making and barn hay drying.

This progress report gives the results of the study to date for the second cutting of the 1945 alfalfa crop which is also being used in the feeding experiments. Results obtained to date on the first cutting are in substantial agreement with the data being presented.

It is expected to continue these studies for at least three years and final conclusions will be based on the results for all years. These preliminary results are given as a progress report to acquaint those interested with the trend of results in the important field of methods of forage preservation.

The second cutting of alfalfa, which contained from 20 to 25 per cent ladino clover, was harvested on June 25 to 29 when the alfalfa was from one-tenth to one-fourth bloom. In order to sample the forage on the field as uniformly as possible for each of the three curing methods and to obtain the original field yield and composition of the freshly cut material, the field was divided into seven blocks, each block of which was divided into three plots of about equal size, as shown in Fig. 1.

The blocks were long and narrow to facilitate mowing. The plots in each block were assigned each of the three harvesting methods at random. Laying out the field in this manner made it easier to have comparable material for each harvesting treatment since all three plots in each block were cut at the same time. A total of 37.2 acres were harvested, 12.3, 12.4 and 12.5 acres, respectively, for silage, barn-cured hay and field-cured hay. As the forage was cut in each plot 30 quadrates, each containing 12½ sq ft, were selected at random and the herbage from these areas was collected and composited into three samples containing 10 quadrates each. From these samples determinations were made of the yield, dry matter content, chemical composition,, carotene content, color and leafiness of the green forage at the time of harvest, for each harvesting method. The forage was weighed when it was put in storage and was weighed again when it was taken out of storage. Each kind of forage was carefully sampled when put in and taken from storage in order to determine the dry matter content, chemical composition, carotene content, color and leafiness. From these data the losses in yield of dry matter and nutrients and the changes in the composition, color and leafiness of the forages at different stages of harvesting and storing were determined.

In harvesting and storing the forage the mower, side-delivery rake, ensilage cutter and hay hoist were operated by tractor power. The forage was hauled from the field to storage by truck. The crew in the field consisted of one man operating the mower and side-delivery rake, one man

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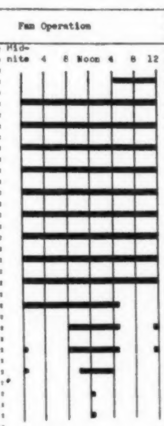
R. E. HODGSON and J. B. SHEPHERD are of the Bureau of Dairy Industry, L. G. SCHOENLEBER and H. M. TYSDAL of the Bureau of Plant Industry, Soils and Agricultural Engineering, and W. H. HOSTERMAN of the Production and Marketing Administration, U. S. Department of Agriculture. L. A. Moore, H. G. Wiseman and C. G. Melin, of the Bureau of Dairy Industry; and R. B. Gray, of the Divisions of Agricultural Engineering, and M. A. Hein, R. E. Wagner and H. L. Wilkins of the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, USDA, cooperated in this study.

A			B			C			D			
1	3	2	3	1	2	3	2	1	2	3	1	
E			**F**			**G**						A to G - Blocks
3	1	2	3	1	2	1	2	3				1 - Silage, 12.3 A
												2 - Barn-cured hay 12.4 A
												3 - Field-cured hay 12.5 A
												• - Sample areas

Fig. 1 Scheme of random selection of plots in blocks of alfalfa harvested as silage, barn-cured hay and field-cured hay



Date	Number Hours	Relative Humidity (80% or more) No. Hrs.	Temp. Deg. F. (8 AM - 8 PM) Max.	Min.	Ave.	Relative Humidity % (8 AM - 8 PM) Max.	Min.	Ave.
6-26	7.7	3	89	74	83	90	54	67
6-27	24	10	87	72	80	84	52	59
6-28	23.5	8	88	71	83	56	33	42
6-29	23.5	8	92	69	85	80	42	56
6-30	24	10	95	73	88	84	47	61
7- 1	24	11	97	78	90	76	43	56
7- 2	24	7	95	81	91	74	43	55
7- 3	24	14	91	73	82	85	53	69
7- 4	24	10	81	74	76	66	37	47
7- 5	24	8	81	65	77	80	47	59
7- 6	17	10	85	73	79	87	64	76
7 -7	9.5	.5	86	75	81	82	64	67
7- 8	10	1	84	76	81	66	35	48
7- 9	6.5	.5	88	70	81	72	37	48
7-10	.5	---	86	73	79	81	57	70
7-11	.5	---	83	73	78	87	60	76
Total	266.7	Ave. 10 Hrs.						

Fig. 2 Pertinent data on mow curing of second-cutting alfalfa in 1945

operating each truck with two men in the field to load. The crew at the silo consisted of one man operating the tractor and filler, one man assisting the truck driver unloading and one man in the silo. The crew used for storing the barn-cured hay consisted of one man operating the hoist, the truck driver operating the fork and three men scattering the wilted hay in the mow. The crew for storing the field-cured hay was the same as for the barn-cured hay, except that one man less was needed in the mow. A record was kept of the time that labor and machinery was used in each operation involved in harvesting and putting the forage into storage. A charge of 12 min was made against each truck load of forage to cover the time consumed in going to and from the field. Any lost or idle time occurring during the operations was not included.

When the first few loads of barn-cured forage was placed on the hay drier, the fan was started up and it was operated continuously until the hay was considered dry (when the forage on the top one foot reached 20 per cent or less of moisture). Thereafter the fan was operated intermittently until the hay showed no indications of heating. The barn-cured hay was taken off the drier, baled and weighed 30 days after drying began and the field-cured hay was taken out of the mow, baled and weighed 25 days after it was stored. The silo was opened 125 days after filling was completed. The weight of silage is being determined as the silage is taken out and fed each day.

TABLE 1. WEATHER CONDITIONS DURING HARVESTING (TEMPERATURE AND HUMIDITY)

	June 25		Juue 26		Jnue 27		June 28		June 29	
	deg F	%	deg F	%	deg F	%	deg F	%	deg F	%
Early morning:										
min. temp.; max. hu.	64	100	64	100	52	100	61	100	67	100
Daytime:										
max. temp.; min. hu.	86	68	82	60	87	42	95	46	97	50
24-hr average:										
6 a.m. - 6 a.m.	74	90	68	87	72	75	78	78	82	84
6 a.m. temp.; hu.	68	100	68	100	57	100	62	100	66	100
9 a.m. temp.; hu.	80	86	73	100	76	62	80	70	79	87
12 m. temp.; hu.	84	74	80	70	79	51	88	53	92	59
3 p.m. temp.; hu.	81	86	79	74	83	46	91	52	95	52
6 p.m. temp.; hu.	77	83	78	60	83	50	86	71	92	67
9 p.m. temp.; hu.	69	100	66	100	69	100	82	74	82	100
Sky conditions during day	Partly cloudy		Partly cloudy		Clear		Clear		Clear	
Radiation; G. cal.:										
Hourly maximum	44		58		83		80		73	
Total for day	363		447		728		647		606	
Water evaporation:										
Inches per day	0.059		0.313		0.268		0.288		0.238	
Air movement:										
Direction	East		NW		NE		SW		SW	
Miles per day	33		68		31		43		35	

The weather conditions from June 25 to 29 when the crop was harvested was generally very favorable (Table 1). The first two days were more or less cloudy. Rain threatened on the second day, but none fell. The last three days were bright and sunny. The humidity, however, remained rather high during most of the harvesting period.

The forage was harvested and stored by each of the three methods in the approximate condition desired, although this was rendered difficult because all three kinds of forage were harvested simultaneously and because the crews stopped working at 4:30 p.m.

The forage harvested for silage was wilted slightly in the field before being stored in the silo without any preservative. About two-thirds of this forage was cut in the morning or right after noon and stored in the silo within three hours after cutting, during which it was in the swath 1.6 hr and in the windrow 1.4 hr (Table 2). About one-third of the forage was cut in the middle of the afternoon, windrowed before 4:30 p.m. after 1.3 hr in the swath and hauled to the silo the next morning while the dew was still on. This raised the average time in the field of all forage to 7.3 hrs, during which it was in the swath 1.5 hr and in the windrow 5.8 hr.

TABLE 2. TIME INTERVALS IN HOURS BETWEEN CUTTING, RAKING AND STORING FORAGE HARVESTED AS SILAGE, BARN-CURED HAY AND FIELD-CURED HAY

	Average time in field, hr			
Method of harvesting	In swath	In windrow	In swath and windrow	From cutting to storage
Silage total:	1.54	5.79	[illegible]33	7.80
Stored same day cut	1.58	.140	[illegible]98	3.45
Cut in afternoon, stored next day	1.41	17.37	18.78	19.26
Barn-cured hay, total:	23.16	4.86	28.02	28.85
Stored day after cutting	20.38	5.39	25[illegible]	26.66
Stored second day after cutting	44.96	.69	45.65	46.03
Field-cured hay, total	26.98	24.35	51.33	54.66

The barn-cured forage was in the field an average of 28 hr after cutting, 23.1 hr in the swath and 4.9 hr in the windrow. The field-cured forage averaged a total of 51.3 hr in the field during which it was in the swath 27 hr and in the windrow 24.3 hr.

The average moisture content of the forage when cut was 77.6, 78.2 and 76.8 per cent (wet basis), respectively, for the silage, barn-cured and field-cured forage. The average moisture content of the forage when taken off the field and stored was 60.6, 43.6 and 19.2 per cent, respectively.

The silage was stored in a 10x25-ft cement stave silo. It was chopped in 1/4-in lengths and no preservative was added. The barn-cured hay was piled in the mow to a height of about 9 ft. The pertinent data regarding the mow drying is shown in Table 3 and Fig. 2. The fan (Buffalo No. 6 backward double-curved multivane fan of a non-overloading type) delivered 15 to 16 cu ft of air per minute per square foot of mow space and was operated for a total of 267 hr over a 13-day period in bringing the moisture content of the hay down to a safe storage point. This represented a current consumption of 73 kw-hr per ton of dried hay. It is probable that considerable savings in current consumption could have been made by not operating the fan continuously during the night when the humidity was high. Most of the hay was high in green color with a good aroma. However, considerable dustiness developed in the top one-third of the mow and it had a musty odor, but no mold occurred. This also occurred to a slight extent in the field-cured haymow; however, both hays appear quite palatable.

TABLE 3. BARN CURING — CHANGES IN WEIGHT AND MOISTURE IN HAY, DRYING TIME, FAN AND POWER REQUIREMENTS

Dates hay was put on drier	June 26, 27, 28
Weight of hay as put on drier, tons	21.11
Moisture in hay as put on drier, per cent	43.63
Weight of hay as taken off drier, tons	12.37
Moisture in hay as taken off drier, per cent	12.73
Height of hay in mow, ft:	
When put in	9
When dried	7
Moisture in top foot of hay, when drying was completed, per cent	19.79
Days required for drying	13
Days fan operated continuously	10
Days fan operated intermittently	3
Total hours of operation	266.8
Cubic feet of air delivered, per sq ft per min	15-16
Electricity consumption, kilowatt-hour	903
Electricity consumption, per ton of hay	73

The field loss of dry matter for the forage made into silage averaged 4.7 per cent (Table 4). The loss due to ensiling (including top spoilage) averaged 10 per cent. The gross loss in dry matter from the field through storage amounted to 14.1 per cent. The gross loss for the barn-cured forage was 20.8 per cent with a field loss of 12.6 per cent and a further reduction of the dry matter during barn drying of 9.3 per cent. The gross loss for the field-cured hay was 23.4 per cent, of which 19.3 per cent occurred in the field with a further reduction in dry matter in the mow of 5.1 per cent.

TABLE 4. YIELD OF DRY MATTER, POUNDS PER ACRE

	Silage	Barn-cured	Field-cured
When cut	2121	2206	2140
When placed in silo or mow	2026	1927	1727
Loss in field, per cent	4.7	12.6	19.3
When taken from silo or mow	1823	1748	1639
Loss during storage, per cent	10.0	9.3	5.1
Gross loss, percent	14.1	20.8	23.4

The protein content of the dry matter, as shown in Table 5, was about the same for all three lots when the forage was cut (21.92, 21.73 and 21.64 per cent). That made into silage changed very little during the time it remained in the field, being 21.9 per cent when cut compared with 21.4 per cent when ensiled. It is not expected that a further reduction in the percentage protein content of the dry matter will occur in the silo.

TABLE 5. PROTEIN CONTENT OF DRY MATTER, PER CENT

	Silage	Barn-cured	Field-cured
When cut	21.92	21.73	21.64
When placed in silo or mow	21.42	20.82	18.69
Decrease	2.3	4.2	13.6
When taken from silo or mow	(22.19)*	21.63	19.68
Change during storage	(+3.1)*	+3.9	+5.3
Gross change	(+1.2)*	-0.5	-9.1

*Estimated

The protein content of the forage stored on the hay drier was 20.82 per cent, or about 4.2 per cent lower (on a dry matter basis) than when it was cut. During storage on the drier, losses of non-protein organic matter were proportionately greater than losses in protein, resulting in the hay having about the same percentage protein content as the original crop.

The protein content of the field-cured forage was 18.69 per cent, or 13.6 per cent lower when stored than when it was cut. Practically no loss of protein occurred during storage, and due to losses of non-protein dry matter, the per cent of protein in the hay baled out of the mow was 19.68 per cent, or only 9.1 per cent less than that of the original crop.

TABLE 6. YIELD OF PROTEIN, POUNDS PER ACRE

	Silage	Barn-cured	Field-cured
When cut	464.9	479.4	463.1
When placed in silo or mow	434.0	401.2	322.8
Loss in field, per cent	6.6	16.3	30.3
When taken from silo or mow	404.5	378.1	322.6
Loss during storage, per cent	6 6	5.8	.03
Gross loss, per cent	13.0	21.1	30.3

The total yield of protein per acre, as shown in Table 6, was reduced because of field losses before storing by 6.6 per cent for forage stored in the silo compared with 16.3 and 30.3 per cent, respectively, for the forage stored on the barn drier for further curing, and the field-cured forage stored in the mow. In the mow there was a further loss of 5.8 per cent in the barn-cured forage with a loss of only 0.06 per cent for the field-cured hay. The loss of protein in the silage amounted to 6.6 per cent. The over-all loss of protein for the crop preserved as silage amounted to 13 per cent, compared with 21.1 per cent for the barn-cured forage and 30.3 per cent for the field-cured forage. Field losses of dry matter and protein are due to leaf shatter, fermentation and unavoidable losses of forage when taking it off the field.

The carotene content of the crop was 307.9, 303.0 and 302.3 μg (micrograms) per gram of dry matter, respectively, as cut for silage, barn-cured hay and field-cured hay (Table 7). By the time these crops were stored, the carotene content had been reduced to 218.2, 121.6 and 49.6 μg per gram, respectively, representing field losses of 29.1, 60 and 83.6 per cent, respectively, for the forage made into silage, barn-cured hay and field-cured hay. After being stored for one month in the mow the carotene of the barn-cured hay was reduced to 29.3 and the field-cured hay to 25.5 μg per gram, representing losses of 90.3 and 91.6 per cent, respectively, of the carotene in the crop as it was cut. Our experience indicates that it is probable a shorter barn-drying period would result in better carotene preservation. The carotene content of the silage averaged 86 μg per gram of dry matter, or an over-all reduction of 72 per cent from the carotene content of the crop as cut. The determination of the vitamin A value of the milk produced by cows fed these three kinds of preserved roughage will point out the significance of their carotene content.

TABLE 7. CAROTENE CONTENT OF DRY MATTER, GAMMA PER GRAM

	Silage	Barn-cured	Field-cured
When cut	307.9	303.0	302.3
When placed in silo or mow	218.2	121.6	49.6
Decrease, per cent	29.1	60.0	83.6
When taken from silo or mow	86	29.3	25.5
Gross decrease, per cent	72	90.3	91.6

When removed from storage, the barn-cured hay averaged 56 per cent green color and 50 per cent leaves, with an official U. S. grade of No. 2 extra leafy alfalfa-clover mixed hay (Table 8.) It contained more leaves than required for a No. 1 grade, but failed to make that grade because it was slightly too low in green color.

TABLE 8. COLOR, LEAFINESS AND OFFICIAL GRADE OF HAYS WHEN TAKEN FROM THE MOW

	Color, per cent	Leafiness of alfalfa, per cent	U. S. Grade
Barn-cured hay	56	50	U.S. No. 2 extra leafy alfalfa-clover mixed
Field-cured hay	54	36	U.S. No. 2 alfalfa-clover mixed

The field-cured hay averaged 54 per cent green color and 36 per cent leaves, with an official U. S. grade of No. 2 alfalfa-clover mixed hay. It was too low in both color and leaves for a No. 1 grade.

Figures on the leafiness of the silage are not yet available. However, data on silage made from first-cutting alfalfa indicate that it is at least as leafy as barn-cured hay.

The total man-hours per acre required to harvest the alfalfa crop and put it into storage by the three methods, as shown in Table 9, amounted to 4.5, 4.6 and 3.9 hr, respec-

TABLE 9. LABOR AND MACHINERY REQUIRED IN HARVESTING, TOTAL HOURS PER ACRE HARVESTED*

	Silage	Barn-cured	Field-cured
Man-hours	4.53	4.61	3.90
Tractor hours (all operations)	1.14	1.12	1.17
Mower hours (tractor operated)	.38	.38	.38
Rake hours (tractor operated)	.33	.38	.52
Loader hours (truck drawn)	.42	.36	.44
Truck hours (loading, hauling, unloading)	1.23	1.02	.97
Silo filler hours (tractor operated)	.43		
Hay hoist hours (tractor operated)		.35	.27

*Acres harvested: silage, 12.3; barn-cured hay, 12.4; field-cured hay, 12.5.

tively, for silage, barn-cured hay and field-cured hay. The total tractor hours required per acre were 1.14, 1.12 and 1.17, and mower hours 0.38, 0.38 and 0.38, respectively, being nearly the same for each method. The hours required for raking were 0.33 for the silage, 0.38 for the barn-dried hay and 0.52 for the field-cured hay. The higher requirement for the hays was due to the fact that all of the field-cured hay and part of the barn-cured hay was turned over after it was raked, whereas the forage made into silage was not turned. The truck requirements per acre were 1.23 hr for the silage, 1.02 hr for the barn-cured hay, and 0.97 hr for the field-cured hay. The silage requirements were higher because more loads were hauled to storage while the field-cured hay required the least truck hours because of fewer loads. Use of the cutter for silo filling amounted to 0.43 hr per acre as compared with 0.35 hr for the use of the hoist in putting up barn-cured hay and 0.27 hr in putting up the field-cured hay.

When calculated in terms of dry matter stored, as indicated in Table 10, the man-hours per ton were about the same for the silage and field-cured method, 4.5 hr per ton each, while the barn-cured method required a total of 4.8 hr. The total tractor, mower and rake hours required per ton of dry matter stored were the least for the silage, 1.13 hr, and the greatest for the field-cured hay, 1.36 hr, while the barn-cured method was intermediate, 1.16 hr. The field-cured hay method required the largest amount of time for loading 0.51 hr, and the barn-cured method the least, 0.38 hr, and intermediate for silage, 0.42 hr, while the total truck hours required were for silage, 1.22 hr, for the barn-cured hay, 1.06 hr, and 1.12 hr for the field-cured hay. More hours were required of the cutter to store the silage than was used by the hoist to store either the barn-cured hay or the field-cured hay, 0.43 hr compared with 0.38 and 0.32 hr, respectively. The total differences in the labor and machinery required to harvest and put the forage into storage by the three methods were remarkably small, and it does not seem that from this standpoint one method is to be favored over the other.

TABLE 10. LABOR AND MACHINERY REQUIRED IN HARVESTING, TOTAL HOURS PER TON OF DRY MATTER STORED*

	Silage	Barn-cured	Field-cured
Man-hours	4.48	4.79	4.50
Tractor hours (all operations)	1.13	1.16	1.36
Mower hours (tractor operated)	.38	.40	.44
Rake hours (tractor operated)	.32	.39	.60
Loader hours (truck drawn)	.42	.38	.51
Truck hours (loading, hauling, unloading)	1.22	1.06	1.12
Silo filler hours (tractor operated)	.43		
Hay hoist hours (tractor operated)		.38	.32

*Tons dry matter stored: silage, 12.42; barn-cured hay, 11.90; field-cured hay, 10.82.

It appeared that harvesting and storing the forage as silage preserved for feeding slightly more dry matter and protein per acre and materially more of the carotene in the original crop at very little if any greater outlay in hours of labor or machinery in putting up the crop. Only feeding experiments now in progress can determine whether or not one type of forage is more desirable as a feed than another.

Farm Work Simplification

(Continued from page 201)

ing the most of sound agricultural science and inherently good materials, equipment, land, and other working capital.

Farm work simplification breaks down, on analysis, into questions, first of all, of functional justification. Is the specific job worth doing? Is there a good reason, in the present work objective, for all of the individual movements or operations within the job? Does each contribute more than its cost to yield, quality value, marketability, conservation of assets, or other good and valuable consideration of increased return or savings? Is the purpose clear, in measurable terms of physical or chemical environment, location, position, timing or other factors favorable to the optimum production or utilization desired? Or is the job, or any part of it, horse baggage carried over by custom, or lack of knowledge or some better way, from some other crop, operation, condition, or day when current knowledge, materials and equipment were not available?

Once the purpose or objective of the job is clearly defined, the inquiring engineer asks himself, "Is this necessarily the best way to accomplish the purpose?" What other ways are available? In the whole field of agricultural practice, engineering development, and other arts and applied science, what techniques, materials and equipment are used in basicly similar situations? Or is the job sufficiently unique, time consuming, and necessary to warrant some entirely new approach? Does it warrant research for new basic data? Does it indicate need of new materials, equipment, power applications, or controls?

Further immediate opportunity for agricultural engineers to help farmers simplify their work exists in refinement of established operations of tillage, planting, harvesting, feeding, etc., which must and will go on while awaiting benefit of engineering analyses of justification and alternative methods. Refinements of routing and layout, integration or combination of simultaneous operations, sequence of operations, coordination of operations in multiple-man jobs, critical and non-critical time factors, time and motion study, reduction of weather hazards, scale of operation, yield and area influences on work, routine maintenance to reduce breakdowns, improved carriers, automatic controls to reduce personal tending of operations — all these and more are particularly matters in which engineering techniques can help farmers save minutes here and there to apply where they can be more useful, and to add up to material increases in farm operating efficiency.

There is a practical kind of opportunism in giving farmers the sort of engineering help they want, when they want it. It represents work simplification for the engineer, reducing the effort required to sell his ideas and making more of his time and energy available to increase and improve his technology and service. With this in mind we might well make agricultural engineering attention to work objectives, basic jobs, and refinement of work methods an order of the day.

Freezing Rates of Foods in a Locker Plant with Direct Air Blast

By John E. Nicholas
FELLOW A.S.A.E.

CONTACT with a single refrigerated plate or pipe coil, and direct air blast, are the two methods generally practiced in freezing meats, fruits and vegetables in locker plant freezing rooms. At the present, room temperatures of –10 to –15 F (degrees Fahrenheit) are usually considered the basis of design for locker plant freezers.

As a result of the general conviction that the more rapidly foods are frozen the better the quality of the products, it is important for engineers to know the rate at which heat is extracted from certain products under various conditions in order to prepare correct specifications for evaporator surfaces and to select proper compressor capacity.

Several factors are recognized as affecting speed of freezing in an environment. For a given weight of packaged product, the type of container, its shape, the number of layers of wrapping material used while freezing, and the arrangement of the packages (in a single layer or piled on top of each other) are the greatest factors controlling the speed of freezing or the rate at which heat is given off.

Freezing Rate Studies. Freezing rate studies on fruits and vegetables were carried out in a locker plant having a freezing room approximately 8 ft wide, 10 ft long, and 7 ft high. Freezer coils and fan were located in a false ceiling. Circulation was attained by air passing upward through an opening in this ceiling near the door, over the coils, and into the fan which forced it downward onto the products to be frozen. Air blast was provided by a double Sirroco-type blower discharging through two 12x14-in openings.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and authorized for publication on January 24, 1945, as technical paper No. 1271 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

JOHN E. NICHOLAS is professor of agricultural engineering, Pennsylvania State College.

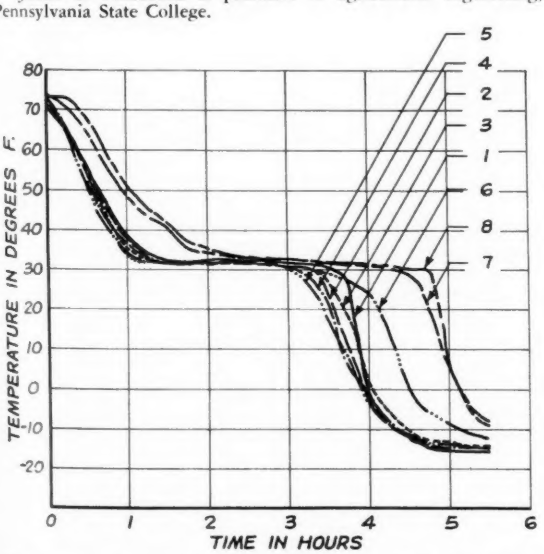


Fig. 1 Rates of freezing of Brussels sprouts packed dry in pints and quarts, February 2, 1944. Curves 7 and 8, type a packages qt; curves 1 and 2, type b packages, pt; curves 3 and 4, type d packages, pt; curves 5 and 6, type e packages, pt

The freezer room temperature was thermostatically controlled but the fan was manually operated, being turned on only when packages of food were being frozen.

During freezing, packages were placed on the upper shelf of a wooden rack in a single layer, separated from each other, directly beneath the fan exhaust opening 24 in distant. The air velocity over the product during freezing varied from 1500 to 1800 fpm (feet per minute). Air-blast temperatures measured at points between packages were found to vary from +3 to –15 F during the trials.

Type of Packages Used. Many types of commercially available packages have been found acceptable and satisfactory for the freezing and storage of foods. In these experiments, however, the number was limited to three types and to quart and pint capacities.

Two types used were brick shaped, containers made of heavy cardboard with vaporproof cellophane bags on the inside. The third was cube shaped and of heavy cardboard construction and heavily paraffined both inside and out. For convenience of study and analysis, the symbols in Table 1 will be used to refer to the curves in the figures which show the rates of freezing of various fruits and vegetables in the type and sizes of containers.

TABLE 1. LETTERS RELATING PACKAGE TYPES TO THE FREEZING RATE CURVES IN FIGS. 1 TO 8

(Note that the same curve "number" in the 8 figures does not necessarily represent the same type of package in each figure)

Package, type "a", cube shaped, paraffined, quart=$3\frac{3}{4}$x$3\frac{3}{4}$x$4\frac{1}{8}$ in

Package, type "b", cube shaped, paraffined, pint=$3\frac{1}{4}$x$3\frac{1}{4}$x$3\frac{1}{4}$ in

Package, type "c", brick shaped, with cellophane lining, quart=4x$7\frac{1}{2}$x2 in

Package, type "d", brick shaped, with cellophane lining, pint=$3\frac{3}{4}$x4x2 in

Package, type "e", brick shaped, with cellophane lining, pint=4x$5\frac{1}{2}$x$1\frac{3}{4}$ in

NOTE: Package "e" was made of a heavier cardboard than "c" and "d" had a gloss finish.

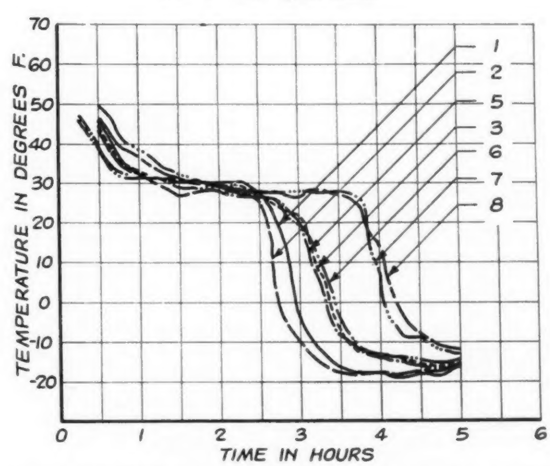


Fig. 2 Rates of freezing of broccoli, packed dry in pints and quarts, February 3, 1944. Curves 7 and 8, type a packages, qt; curves 1 and 2, type b packages, pt; curves 3 and 4, type d packages, pt; curves 5 and 6, type e packages, pt

Method of Preparation. All prepared vegetables were steamed in a 3-gal covered kettle for 3 min in lots of 200 g (7 oz approximately). The products, contained in cheesecloth squares, were placed on a wooden rack which kept the material from coming in direct contact with the boiling water.

Upon removal from the steaming kettle, the products were immediately plunged into ice water. After sufficient cooling, the vegetables were removed from the cheesecloth and placed on wire strainers to drain before packing.

In the case of pineapple, the one kind of fruit used in this study, it was peeled, cubed, then packed without sugar or syrup. The pints in general contained 200 g and quarts 400 g, except as noted, depending on the bulk and density of the product.

Each freezing rate curve represents the temperature of a single piece located at or near the geometric center of an individual package.

Experimental Results. Figs. 1 to 8 show the rates of freezing of pint and quart packages of the products indicated. The first part of the curve, from 1 to 2 hr, covers pre-cooling to the freezing point, the approximately horizontal part covers the freezing operation, and the lower portion cooling below freezing.

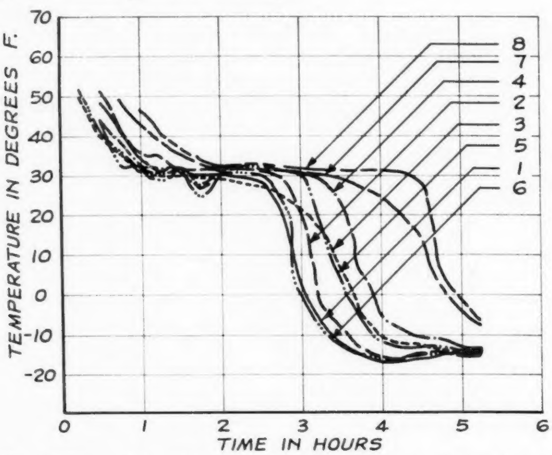


Fig. 3 Rates of freezing "Frenched" snap beans in pint and quart containers, February 4, 1944. Curves 7 and 8, type a packages, qt; curves 1 and 2, type b packages, pt; curves 3 and 4, type d packages, pt; curves 5 and 6, type e packages, pt

Figs. 1 to 3 do not give the air-blast temperatures during the freezing process, but variations are graphically indicated in Figs. 4 to 8, inclusive.

Brussels Sprouts. Quantities of Brussels sprouts, 230 g in pints and 520 g in quarts, were dry packed. Rates of freezing are illustrated in Fig. 1. The quart packages required one hour longer to freeze than any of the pint packages. The pint packages reached 0 F in approximately 4 hr and the quart packages in 5¼ hr.

Broccoli. The quantities of broccoli dry packed in pint and quart packages were 167 and 334 g, respectively. Fig. 2 shows graphically the rates of freezing; as with Brussels sprouts, the quart containers required one hour longer to freeze than the pints. The pint packages reached 0 F in approximately 3¼ hr and the quart packages in approximately 4¼ hr, or ¾ hr faster than the Brussels sprouts.

Frenched snap beans. Rates of freezing of "Frenched" snap beans, dry packed in quarts and pints, are shown in Fig. 3. Each pint container held 198 g and each quart 400 g. As with broccoli and Brussels sprouts, freezing quart packages required a greater length of time than the pint packages as indicated by curves 7 and 8. All packages attained 0 F before the fifth hour.

Lima beans. Fig. 4 shows rates of freezing of lima beans, dry packed, in pints and quarts, 200 and 400 g each, respectively. The quart containers represented by curves 7 and 8 were frozen last. They were brick shaped as against

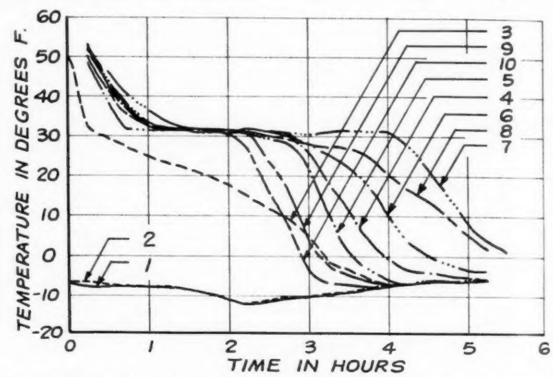


Fig. 4 Rates of freezing lima beans, dry packed in pints and quarts, April 4, 1944. Curves 7 and 8, type c packages, qt; curves 3 and 4, type d packages, pt; curves 5 and 6, type e packages, pt; curves 9 and 10, type b packages, pt

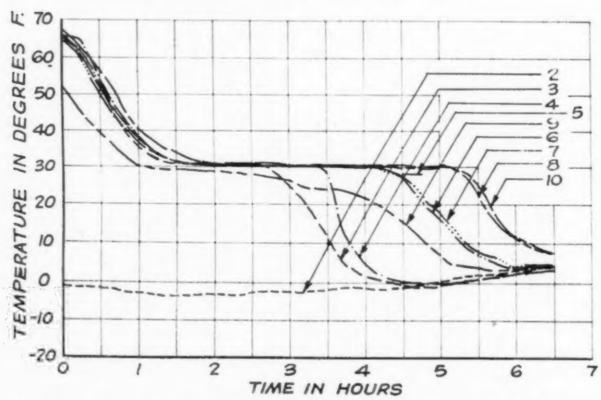


Fig. 5 Rates of freezing of diced carrots, dry packed in pints and quarts, April 5, 1944. Curve 2, air blast in freezing room; curves 3 and 4, type b packages, pt; curves 5 and 6, type d packages, pt; curves 7 and 8, type e packages, pt; curves 9 and 10, type c packages, qt

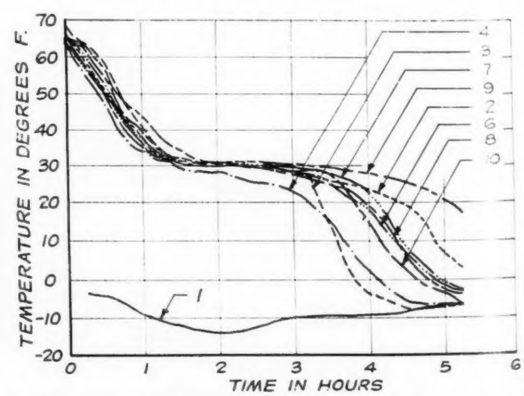


Fig. 6 The rates of freezing of cubed pineapple dry packed in pints and quarts, April 6, 1944. Curve 1, air blast temperature; curves 2 and 6, type d packages, pt; curves 3 and 4, type b packages, pt; curves 7 and 8, type e packages, pt; curves 9 and 10, type a packages, qt

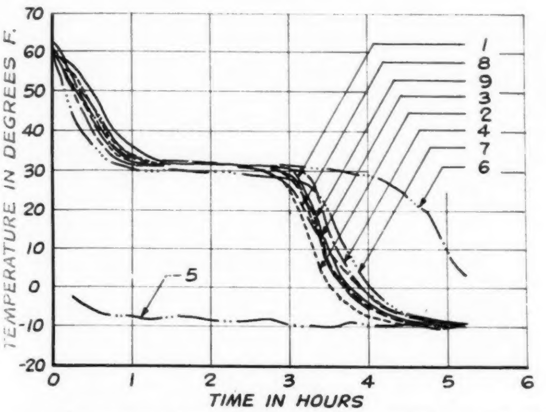


Fig. 7 The rates of freezing of spinach, dry packed in pints and quarts, April 11, 1944. Curve 5, air blast temperature; curves 1 and 2, type b packages, pt; curves 3 and 4, type d packages, pt; curves 6 and 7, type e packages, pt; curves 8 and 9, type c packages, qt

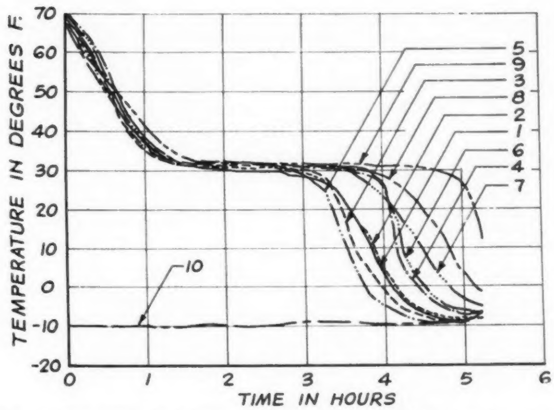


Fig. 8 The rates of freezing of cauliflower, packed dry in pints and quarts, April 12, 1944. Curve 10, air blast temperature; curves 1 and 2, type b packages, pt; curves 3 and 4, type d packages, pt; curves 5 and 6, type e packages, pt; curves 7 and 8, type c packages, qt; curve 9, type d or e package, pt

the quart containers shown in the three previous figures which were cube shaped.

Curve 3, representing type d package, shown dotted, apparently records measurements of "air-space-temperatures" caused by the dislocation of the thermocouple. Nearly all of the packages attained 0 F in 5½ hr.

Curves 1 and 2 show air-blast temperatures measured on top of the wooden rack near the freezing packages.

Diced carrots. Fig. 5 shows the rates of freezing of diced carrots, dry packed in pints and quarts filled, respectively, with 200 and 400 g of the product. Curves 9 and 10 show the freezing of brick-shaped quart containers, type c. The effect of a higher temperature in the freezer room, curve 2, which ranged from –4 to + 4 F, is definitely indicated. This rising temperature was caused by an additional load on the refrigerating plant. Even the pint packages which were the first to attain 0 F show rising temperature after the fifth hour.

Cubed pineapple. Rates of freezing of cubed pineapple, packed dry, is illustrated in Fig. 6. Pints and quarts contained 250 and 500 g, respectively. The cube-shaped quart, curve 9, was last to freeze. All pint packages, except that shown by curve 2, attained 0 F before the fifth hour. Maximum and minimum temperatures of the air blast during the freezing process were –3.5 and –14.5 F. The effect of a rising air-blast temperature is shown to have influenced the temperature of the frozen packages.

It is interesting to note that the radius of curvature for all these pineapple freezing curves at the time of deviation from the freezing zone is much larger than for products of higher water content, such as Brussels sprouts, broccoli, and snap beans.

Discrepancies between the freezing rate of the quart package, curve 10, and the pint package, curve 2, may have been due to a slight shift in thermocouple location.

Spinach. Fig. 7 shows the rate of freezing of spinach, dry packed, in pint and quart containers, holding 250 and 422 g, respectively. The air-blast temperature, curve 5, varied from –8 to –10 F during the freezing process. With the exception of the package indicated by curve 6, all pint and quart containers attained 0 F in less than 4 hr. Amazingly enough, the quarts, curves 8 and 9, type c packages, froze as rapidly as pints, probably as a result of being placed in a location on the wooden rack having a higher air-stream velocity during freezing.

Cauliflower. This vegetable was found slightly more difficult to cut into uniform pieces than the others studied. The quantities packed in pint and quart containers were 200 and 400 g, respectively. Rates of freezing are shown in Fig. 8 with air-blast temperatures in curve 10. In this experiment a new type of package was introduced, a brick-shaped pint having an inner liner bag of vaporproof paper. Its rate of freezing is indicated by curve 9, and all attained 0 F before 5¼ hr, except this package, showing a marked effect of package material.

GENERAL DISCUSSION AND RESULTS

The observations made in this study are of interest to plant managers since the data were collected under practical operating conditions. They indicate in a measure how long it is necessary for fruit or vegetables to remain in an air blast freezer to remove the latent heat from the product.

Under the conditions of this experiment the precooling time to freezing point of the various packages of different products varied from 1¼ to 2 hr. The actual freezing time during which the temperature of the products remained nearly constant was from 1¼ to 4 hr, depending on the product, type container, and air conditions. Diced carrots, the slowest product to freeze, attained 0 F in 4½ hr from the time they were put in the freezer when packed in pint packages. Diced carrots in quart packages, however, required 2 hr longer to freeze, but broccoli and spinach attained 0 F in 4½ and 4 hr, respectively.

Relatively uniform results were not obtained in the freezer room, however, as shown by the air-blast temperatures, Figs. 4 to 8, because of the manually operated fan and load variations. Air velocities measured 24 in below the ceiling on the top tier of the wooden rack, taken directly beneath the fan outlet, were found to vary from 1500 to 1800 fpm. Air velocity of 400 fpm was found at one end of the top tier of the wooden rack. Velocities on the lower rack were apparently less. Since no packages were frozen on them these were not recorded. There was a noticeable velocity variation on the available freezing area of the top tier of the wooden rack, and it was not possible to locate similar packages on the same exact spots during the different days the studies were carried out; some of the variations which are apparent in Figs. 1 to 8 may be, in part, explained by that fact.

In this type of freezing the square feet of surface per unit weight of the material *(Continued on page 227)*

Haymaking in the Nebraska Sand Hills

By L. F. Larsen
ASSOCIATE A.S.A.E.

THE sand-hill area represents about a quarter of the state of Nebraska, approximately 12½ million acres of the north central portion of the state. Being unadapted to cultivation, the land is, for the most part, still covered with native vegetation. It is utilized primarily for the production of livestock, chiefly cattle.

The sand hills are often likened to a large sponge which will absorb virtually all precipitation as it falls. This vast reservoir of water causes many springs which in turn feed many of the streams that flow in the state.

This area is especially suited for the raising of livestock, not only because of the grass that is available, but also because water can be provided in practically any pasture by sinking a shallow well.

A large percentage of this area consists of dune sand which grows only a light covering of grass and can be used only for grazing purposes. The meadows provide a heavier growth of hay for harvesting, and being interspersed among the dune sand topography, they furnish cattlemen with the necessary feed to carry cattle through the winter months.

Ranches consist of 1000 to 100,000 acres, depending upon the location and the wealth of the owner. In the heart of this area, ranchers expect to have 10 to 20 acres per cow for grazing. If grass is overgrazed the dune sand becomes denuded and wind erosion begins.

The sand-hill rancher usually has good cattle but little farm machinery considering the large acreages. His farm equipment consists mainly of hay-making machinery such as mowers, rakes, stackers, buck rakes, tractors and trucks. Very little of this equipment other than tractor, truck and mower can be purchased commercially. Much of it must be made or converted to suit the needs of the rancher.

Some of the larger operators may have 7 or 8 tractors equipped with power mowers. These tractors are seldom used for anything else than mowing grass and the mower is often not removed from one season to the next. Many ranchers use power mowers and pull a trail mower behind. One enterprising rancher made a power drive for his trail mower for use during the past season. He felt that this was a big improvement over the ground driven type.

Rakes are usually hitched so two or three can be pulled together. Many prefer to rebuild rakes entirely, making one large 30-ft rake with the tractor carrying the center. It is quite common to see auto spindles and hubs used in place of regular axle and hub. The trip catch for dumping is then no longer used, and a hydraulic brake is used from the auto wheel. This makes smoother operation at higher speeds.

Buck rakes are built on either tractors or trucks. Many ranches are located far from town and cannot conveniently go to the local shop for repair work. Ranchers try to make themselves as self-sufficient as possible with good shops and welding equipment, for many times during bad weather it is impossible to travel far except by horseback. Haying usually begins in July and ends in September. Ranchers put their equipment in good working order during the winter months to prevent costly failures during hay harvest.

Very few buck rakes have power lifts but are built as simply and ruggedly as possible. It is not uncommon to see 4x6-in lumber used for buck rake teeth. The buck rakes are nearly always mounted on the rear of the tractor or truck with differential gears turned over to give the higher speeds when traveling backward. Tractors or trucks equipped with buck rakes are seldom used for any other purpose. A heavy-duty truck is preferred to a smaller truck or car chassis.

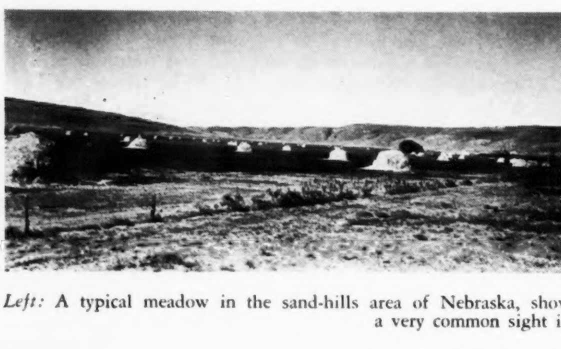
Stackers are mainly of the slide type. They are built of heavy timbers to withstand hard usage and are generally built on the ranch. Because of the weight it is never necessary to stake them down as is customary with smaller, lightweight stackers. The slide stacker is preferred because it has few moving parts, is simple, yet rugged enough to resist breakage.

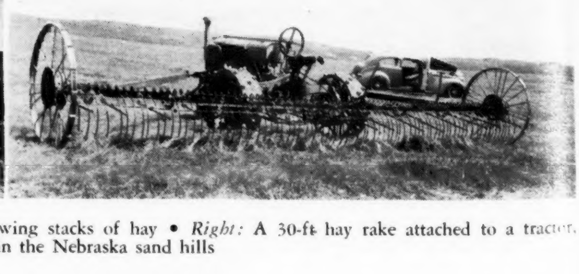
Backstops and cages are almost always used to help in forming stacks and save many man-hours during the haying season. Where it was formerly necessary to have two men on the stack it is now possible for one man to do the work easily when backstops are used. In some cases the one man on the stack also operates the stacker by a tractor powerlift control made from an auto rear end. The control is arranged so that the man on the stack can reach it at all heights of the stack.

During last season the author visited a large hay-making crew where 8 mowers were operating continually. An entire camp had been set up near where the hay was being stacked. This camp provided complete repair service with standby equipment ready to go into instant use. A complete mess hall and bunk houses were on wheels. Two 5-ton International trucks with shortened wheelbase were used to buck hay to a slide stacker. A new stack of ap-

This paper was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946.

L. F. LARSEN is extension agricultural engineer, University of Nebraska.





Left: A typical meadow in the sand-hills area of Nebraska, showing stacks of hay • *Right:* A 30-ft hay rake attached to a tractor, a very common sight in the Nebraska sand hills

proximately 8 tons was set up every 15 minutes, which included time for moving and resetting the stacker.

After the haying season is over many ranchers like to group stacks together in a "stack farm". This is for convenience in loading and also to eliminate need of fencing each stack individually to keep cattle away. Stacks can be moved by either of two methods. The first is to hitch a crawler type tractor to the stack by means of a chain about the stack and slide the stack across the hay meadow. The other common method is to pull the entire stack onto a large trailer by the use of chains and move it to the desired location. These large trailers are standard equipment for hauling hay to the meadow where the cattle are fed during the winter months.

Freezing Rates of Foods in a Locker Plant with Direct Air Blast

(Continued from page 225)

packed in a container should show up as an advantage, but this did not always prove true.

This variability of the results is sure to raise questions in the minds of engineers designing plant equipment. They, however, can form a guide enabling the engineer to better exercise judgment in the selection of equipment. It seems obvious that, if an air blast of known uniform velocity and of suitable uniform low temperature could be directed at a given area at will, much better control of freezing rates than is herein reported would result. Furthermore, it also is apparent that this factor of air motion must be brought under control before any standard can be set up for the measurement of air-blast freezing efficiency.

AUTHOR'S NOTE: The author gratefully acknowledges the technical assistance of Miss Mary Wylie, graduate student in the department of home economics at Pennsylvania State College.

Improved Manure Loader Design Needed

TO THE EDITOR:

LATELY manure loaders have begun to occupy an important place in the farm equipment picture. The advertisements usually show them attached to the front end of a general-purpose tractor; also, they are shown loading gravel or dirt and for handling bales of hay or straw and bundles in the harvesting of grain.

Recently a farmer demonstrated his loader to me. First he ran the loader into the manure pile, picked up a scoopful (perhaps 400 or 500 lb), and elevated it on to the spreader. But when he moved up closer to the pile to take another scoopful, the front wheels of the tractor went down into the muck out of sight, and the outfit had to be pulled out with another tractor. Another farmer in demonstrating his loader to me tipped the outfit over in moving the load on to the spreader.

All this makes me wonder how much thought has been given to the fundamentals of design in the development and application of this equipment. Here is a device built and sold to farmers for about $300 which puts the load on that part of the tractor least able to carry it; in fact, the front end of most general-purpose tractors was never designed to carry such loads. Also, I wonder if any thought was given to the safety of the operator in putting such a heavy load on the front of a g-p tractor.

It seems to me someone could take an ordinary manure spreader equipped with power take-off, and at an additional cost of around $75 to $80 provide a means for loading, so that the spreader could be backed into a manure pile and load itself in 3 or 4 minutes. Such a machine would be less hazardous for the operator, and the spreader would be backed into the soft ground around the manure pile while the tractor would remain on firmer ground.

WISCONSIN AG ENGINEER

Upper left: A common type of buck rake used in the Nebraska sand-hill country. The teeth in the rake are made from 4x6-in pieces. The tractor is used exclusively to buck hay • *Upper right:* This picture shows a slide-type stacker with a backstop and a cage for forming the stacks • *Lower left:* A large stack loaded on a slip or hay wagon for transporting. The stack was put on the slip with a tractor-powered winch • *Lower right:* A view of the slip used for hauling stacks. It is about 16x24 ft in size and can easily haul a 7 or 8-ton stack

A Float Meter for Concrete Pipe Irrigation System Outlets

By C. N. Johnston

MEMBER A.S.A.E.

THE water discharged from so-called alfalfa and orchard valves in concrete pipe irrigation systems can seldom be metered satisfactorily either before or after emergence from the valves. Recent research at the Irrigation Division Laboratory of the University of California at Davis provides data covering the operation of a float meter (Fig. 1) and permits measuring the instantaneous flow from 8, 10, and 12-in valves of these types.

Six variables cover the behavior of such a float, namely, (a) diameter of the valve, (b) weight of the float assembly, (c) flow rate, (d) submergence, or (e) non-submergence of the discharge face of the valve, and (f) measured lift of the float.

Diameter is a constant for any given valve size. Weight of the test float can be increased through any desired range above the minimum assembled weight by adding increments of weight. Flow variations can be measured and controlled in calibrated equipment in the laboratory. The condition of submergence or non-submergence is a matter of observation either in the laboratory or in the field, and the measured lift of the float determines the flow rate for any given set of conditions. Float sizes correspond to valve sizes, thus an 8-inch valve is covered by an 8¼-in diameter float; a 10-in valve by a 10¼-in float, and so forth.

Returning to Fig. 1, the procedure for obtaining measured lift and for observing submergence conditions can be explained. Flow has begun in the figure and is assumed steady. The water level (right) has risen above the top of the valve at the crest of the concrete pipe riser, the distance labelled submersion (right). On the left, the scale has been raised so it just contacts the water level (of the pond). This places the bottom of the scale the distance of the submergence above the leveling stake (left). The pointer is shifted along the scale so it is level with the bottom of the float. This shift of the pointer is the net lift of the float above the pond (water level) which equals gross lift (above the valve face) less the submergence. This is the value for lift to be read when there is submergence.

When the water gets away, there is no submergence and the water level is below the leveling stake (left). The basic zero level becomes that of the upper face of the valve (or top of the leveling stake). Placing the bottom of the scale on the top of the leveling stake, the necessary shift of the pointer needed to place it opposite the bottom edge of the

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

C. N. JOHNSTON is assistant professor of irrigation and associate irrigation engineer in the California Agricultural Experiment Station.

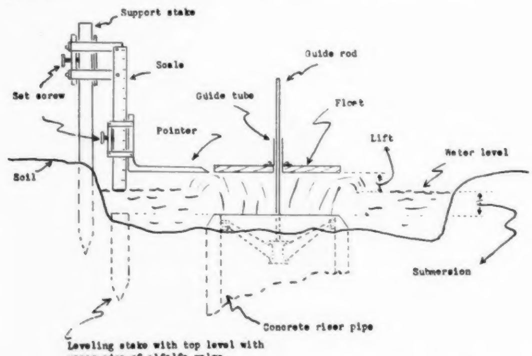


Fig. 1 Field installation of float meter at concrete pipe riser

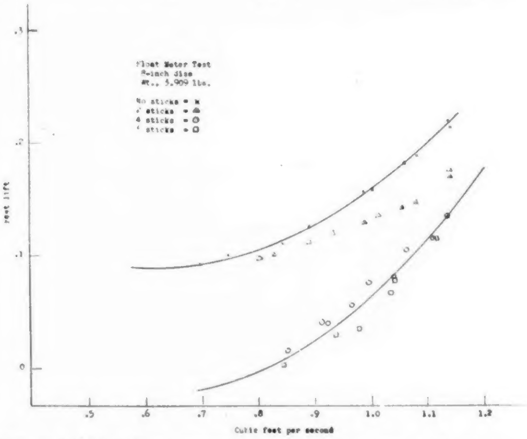


Fig. 2 Lift-discharge curves for 8-in float meter with no submersion (upper curve) and submersion (lower curve). Points plotted from typical test data

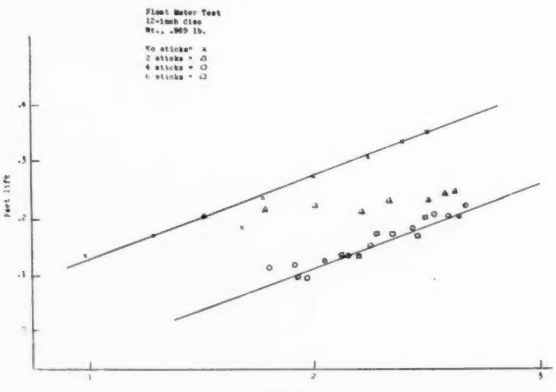


Fig. 3 Lift-discharge curves for 12-in float meter with no submergence (upper curve) and submersion (lower curve). Points plotted from typical test data

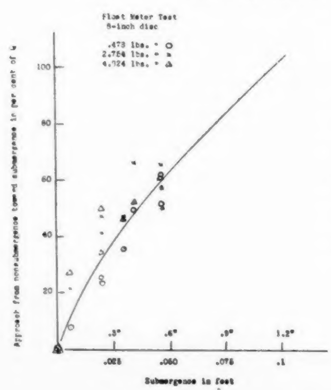


Fig. 4 Correction curve for use with 8-in float meter when submergence is below the minimum required for strictly submerged conditions. It shows a tendency for partial submergence to shift quantity reading from non-submergence curve toward true submerged curve

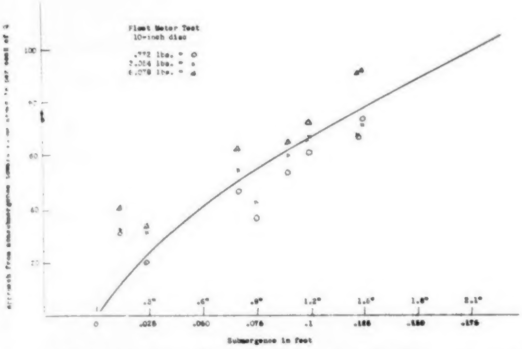


Fig. 5 Correction curve for use with 10-in float meter when submergence is below the minimum required for strictly submerged conditions. It shows a tendency for partial submergence to shift quantity reading from non-submergence curve toward true submerged curve

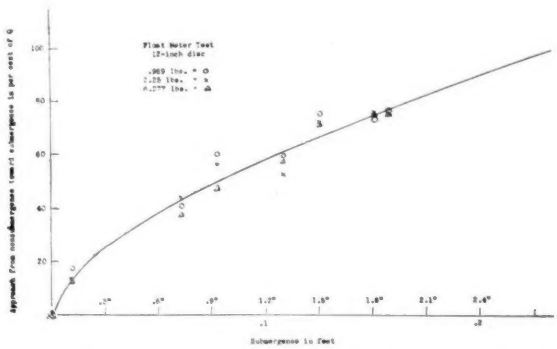


Fig. 6 Correction curve for use with 12-in float meter when submergence is below the minimum required for strictly submerged conditions. It shows a tendency for partial submergence to shift quantity reading from non-submergence curve toward true submerged curve

float measures the net lift of the float for the test. Data from a typical test are shown in table below.

On the basis of these data, if the flow caused a 2.44-ft head (line 1) at the water manometers registering loss through the 8-in flow nozzle (4-in throat), then 1.118 cfs were passing, and when the float had been weighted by adding lead disks to a total of 1398.8 g, the gross lift reading was 0.536 ft. There was a zero lift constant (or zero reading error) of 0.2 ft, so the gross lift actually was 0.336 ft. The submergence for 1.118 cfs flow was 0.158 ft (last column), so the net lift of the float was 0.178 ft. Similar tests carried the three sizes of float through a series of weights and flows with and without submergence. The degree of submergence was controlled in part by the number of 1¼-in wide-flow obstructing sticks located in the escape part of the basin about the valve. In the test given, three sticks were employed. No sticks would assure no submersion in the setup.

Figs. 2 and 3 present the net lift — the Q relationship for 8-in and 12-in disks weighing 3.909 lb and 0.969 lb, respectively, for both submergence and non-submergence. The weights in pounds were obtained by conversion of grams to pounds.

Each figure has two well-defined curves. The upper curve located by the cross marks represents no submersion. The circled dots and squared dots represent two degrees of submersion and the triangular dots a third submersion condition. The triangular dots wander from the no-submergence curve at the left to the submerged curve at the right. The reason they do is that the degree or depth of submergence for this two-stick test ranged from none at low flows to about an inch at higher rates. The path of the triangular dots represents a transition from non-submergence to submergence. They provide a means for correcting readings taken when submergence is below some minimum. Figs. 4, 5, and 6 cover the analysis of these transition curves for three different float weights in the three-float sizes. The data are not so perfect that an exact curve is defined for each

TEST OF 8-INCH FLOAT METER (May 2, 1945)
(Three sticks in outlet of pond to raise water level)

Head on 8-in flow nozzle	Q	Gross lift of disk in feet when it weighs the indicated grams (Zero lift constant = 0.2 ft) (grams)							Submergence	
ft	cfs	216.8	551.6	896.2	1249.2	1398.8	1772.3	2188.5	in	ft
2.44	1.118	0.682	0.641	0.601	0.560	0.536	0.484	0.452	1 15/16	.158
2.18	1.035	0.627	0.582	0.542	0.505	0.483	0.444	0.410	1 13/16	.146
1.84	.967	0.551	0.516	0.484	0.440	0.420	0.393	0.362	1 9/16	.128
1.56	.893	0.478	0.443	0.414	0.385	0.372	0.358	0.336	1 ⅜	.113
1.38	.845	0.418	0.392	0.376	0.356	0.348	0.330	0.314	1 ¼	.102

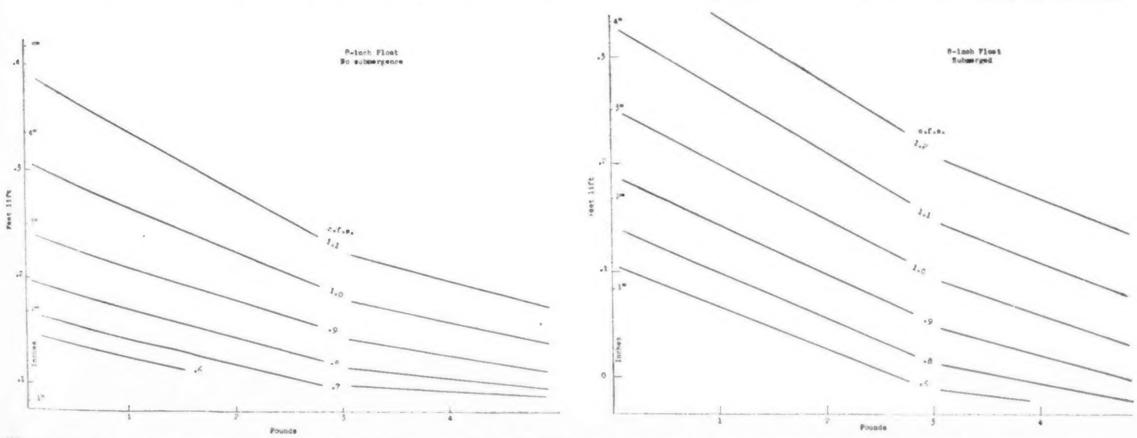


Fig. 7 Discharge rate curves for a range of combinations of 8-in float lift and weight with no submergence (left), with submergence (right)

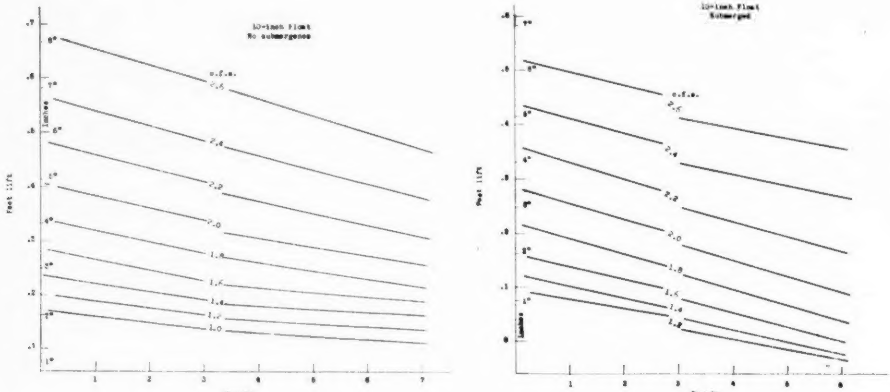


Fig. 8 Discharge rate curves for a range of combinations of 10-in float lift and weight with no submergence (left) and with submergence (right).

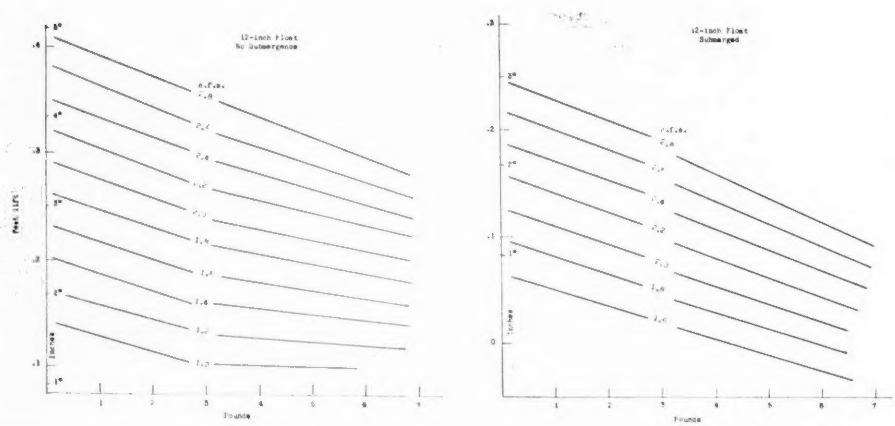


Fig. 9 Discharge rate curves for a range of combinations of 12-in float lift and weight with no submergence (left) and with submergence (right).

float size, but a reasonably accurate curve can be drawn affording a correction that will bring the results to near exactness. The intersection of these curves with the horizontal 100 per cent line indicates the minimum depth for true submergence. For the 8-in floats, this is about 1⅛ in; for the 10-in, about 2¼ in; and for the 12-in, about 2⅞ in If in the field damming of the flow will raise the submergence above their respective minimums, no correction is used. If the submergence cannot be changed, a correction is provided on the chart corresponding to the float size in use. Any submergence above the respective minimums follows the general submergence curve.

The application of data from the complete group of submerged and non-submerged curves obtained from graphs similar to Figs. 2 and 3 is to be found in Fig. 7 for the 8-in float, in Fig. 8 for the 10-in, and in Fig. 9 for the 12-in. The lettered numbered figures portray the conditions for submerged flow, and the numbered figures the corresponding performance for non-submerged flow. The sloped lines represent constant quantity in cubic feet per second. Their use may be illustrated by the following example: 12-in float meter weighing 4.5 lb; submersion, 0.105 ft (this is below the minimum) ; net lift read above water level, 0.125 ft = 1.5 in.

From Fig. 9 (submerged), if the lift is 1.5 in and the weight is 4.5 lb, the flow should be about 2.6 cfs for submergence. From Fig. 9 (non-submerged), and the same lift above the water level, the true net lift equals 1.5 in = 0.125 ft plus 0.105 ft, the partial submergence, equals 0.23 ft, and the weight remaining the same, the flow should be 2.04 cfs for non-submerged conditions.

The operation so far has been based on the assumption that flow was either submerged or non-submerged. The steps undertaken would be followed if either condition prevailed and a correct value would result. Because the submergence is below the minimum specified above, the flow is neither truly submerged nor non-submerged, but somewhere between. It is necessary to turn to the conversion curve (Fig. 6) for this size float to correct for this condition of submersion below the minimum. It is found that a submersion of 0.105 ft requires a shift of non-submerged values over toward submerged values in the amount of 60 per cent. Values obtained: non-submergence, 2.04 cfs; submerged, 2.6 cfs; difference = 0.54 cfs; 0.60 × 0.54 = 0.324 cfs = correction. The true flow = 2.04 × 0.324 = 2.364 cfs. This is accurate within a small percentage.

The detail of Fig. 1 is typical of a field installation rather than of the laboratory test. Some provision would have to be made in the field to quiet the water level adjacent to the bottom of the scale by use of a metal or earthen dam. The float can be made of any material (plywood, sheet iron, plank, and so forth). The guide rod should be at least ¼ in outside diameter and the guide tube should fit it loosely. They both are best made of brass. The lift-measuring scale, pointer, and so forth is a suggested assembly subject to local improvisation. The guide rod was centered in an old piece of threaded alfalfa valve stem in the laboratory and could be moved from valve to valve as the three sizes were tested. In general it is desirable to make the float as light as possible.

NEWS SECTION

THE A.S.A.E. ANNUAL MEETING

Hotel Jefferson, St. Louis, Mo. — June 24 to 26, 1946

THE PROGRAM and other arrangements are practically complete for what promises to be the best attended and most significant meeting in the history of the American Society of Agricultural Engineers. This meeting is the Society's regular annual meeting to be held at the Hotel Jefferson in St. Louis, Mo., June 24 to 26.

Saturday, June 22. A premeeting attraction of interest especially to those engaged in educational work is the special agricultural engineering program to be presented by the Society for the Promotion of Engineering Education in connection with its annual meeting to be held at the same place, June 20 to 23. This program is scheduled to begin with a luncheon at noon on Saturday, June 22, in the Hotel Jefferson, and will be followed by an afternoon conference on the general theme "Engineering in Agriculture." Three addresses are on the program of this conference: Meeting the Engineering Needs of Agriculture, by A. W. Turner; The Value of Accrediting Engineering Curriculums, by Dr. D. B. Prentice, chairman, E.C.P.D. Committee on Engineering Schools; and Industry Requirements for Professional Agricultural Engineers, by J. D. Long, president of A.S.A.E. Following scheduled discussions of these papers by one or two deans of agriculture and several agricultural engineering educators, the session will be thrown open for general discussion of those present.

Sunday, June 23. Meetings of the A.S.A.E. Council and Cabinet will be held during the forenoon and afternoon of Sunday, June 23. Registration for the meeting will begin at 3:00 p.m. on the mezzanine floor of the Hotel Jefferson. An interesting program of entertainment is being provided for Sunday evening for those who arrive that day.

Monday, June 24. Three concurrent programs are scheduled for the forenoon of Monday, June 24: Farm Structures, Power and Machinery, and Soil and Water.

The Farm Structures program will include a symposium on conditioning high-moisture corn, in which H. J. Barre of Purdue University, and W. V. Hukill, C. K. Shedd, and Thayer Cleaver, USDA, will participate. S. A. Witzel and Dr. E. E. Heizer, University of Wisconsin, will present a 5-year summary of the Wisconsin research dairy barn project; S. M. Henderson, Iowa State College, will present a paper on negative radiation and its relation to farm building design, and Dr. Samuel Brody, University of Missouri, and J. R. McCalmont, USDA, will discuss the new animal psycho-energetic laboratory being set up at the Missouri Agricultural Experiment Station. A preview of new developments in farm structures design, equipment, and materials is also scheduled for this session.

The Power and Machinery program will open with a paper on tillage practices for corn by R. A. Norton and G. M. Browning, SCS, USDA, and E. V. Collins, Iowa State College. Leonard W. Kephart, senior agronomist, USDA, will present a paper on weed control with chemicals, and a paper on the drifting of poisonous dusts applied by air planes and land rigs will be presented by Dr. F. A. Brooks, University of California.

The Soil and Water program will include a paper on precipitation-evaporation indices by Wendell C. Munson, BAE, USDA, and a paper on an analysis of runoff data by D. B. Krimgold, soil conservationist, USDA. Part of the program of this session will be devoted to a symposium sponsored by members of the Missouri Terracing and Conservation Contractors Association.

The first general session of the meeting is scheduled for 2:00 p.m. on Monday, June 24. The features of this program include the President's annual address by J. Dewey Long, director of education and market research, Douglas Fir Plywood Association; an address on the USDA agricultural research program by Dr. W. V. Lambert, assistant administrator, Agricultural Research Administration, and an address viewing the future of the agricultural engineering field by Dr. J. B. Davidson, Iowa State College.

The regular A.S.A.E. annual business meeting will follow the afternoon program.

Members of A.S.A.E. student branches attending the meeting will be entertained at a dinner at 6:00 p.m. (June 24), as guests of the International Harvester Co. A series of committee and other group round tables is scheduled for 8:00 p.m. the same evening, and thus far include the following: Rural Electric Division, Committee on Research, Committee on Extension, and the A.S.A.E. student group.

Tuesday, June 25. The forenoon of Tuesday, June 25, will be devoted to three concurrent programs: Power and Machinery, Soil and Water, and Farm Electrification.

Trends in power controls for farm machines will be the exclusive topic for the Power and Machinery program, with a paper on the subject by W. A. Harper followed by a panel discussion, with engineering department representatives of tractor and farm machinery manufacturers constituting the panel.

Four papers are scheduled for the Soil and Water program as follows: Wartime drainage in England, by Elmer W. Gain, associate drainage engineer, USDA; experimental work in land grading for drainage, by I. L. Saveson, project supervisor, USDA; tests for development of an automatic drainage gate by S. H. Anderson, hydraulic engineer, USDA; water application efficiency in irrigation, by Dr. O. W. Israelsen, Utah Agricultural Experiment Station, and sprinkler irrigation by G. H. Bliesner, State College of Washington.

The principal feature of the Rural Electric program will be a paper analyzing types of fans for mow hay curing by Thomas Cranage, district sales manager, Clarage Fan Co., followed by a panel discussion with representatives of fan manufacturers constituting the panel. There are two other papers scheduled for this session, one on problems arising from large loads of short duration by H. J. Gallagher, Consumers Power Co., and the other on moisture losses of vegetables during steaming, quick freezing, and packaging by John E. Nicholas and three members of the home economics department of Pennsylvania State College.

The second general session of the meeting will be held at 2:00 p.m., Tuesday, June 25, and will include two addresses, one on the Missouri Valley Plan by Dr. H. L. Walster, dean of agriculture, North Dakota Agricultural College, and the other on engineering implications in agricultural industries and services by Dr. Paul W. Chapman, dean of agriculture, University of Georgia.

For the evening of June 25, provision is made for all those attending the meeting, who may care to do so, to attend an opera performance at the St. Louis Municipal Open-Air Theater.

Wednesday, June 26. Three concurrent programs are scheduled for Wednesday forenoon, June 26: Power and Machinery, Farm Structures, and Rural Electric.

The Power and Machinery program will open with a paper on farm mechanization, by Nils Berglund, director of the Swedish Institute of Agricultural Engineering, and the remainder of the period will be devoted to a symposium on the mechanization of sugar beet production, the scheduled speakers for which include S. W. McBirney, senior agricultural engineer, USDA; E. M. Mervine, agricultural engineer, Colorado State College; Claude Walz, chief engineer, John Deere Wagon Works; C. E. Guelle, International Harvester Co., and W. E. Urschel, Urschel Laboratories, Inc.

The Farm Structures program will open with a paper by Wallace Ashby, head of the farm buildings and rural housing section, USDA. Additional numbers include a report on the State of Washington farm structures research program by L. J. Smith, State College of Washington, a farm structures plan service, by J. L. Strahan, Flintkote Co., regional coordination of farm buildings publications, plans and research by Henry Giese, Iowa State College, and agricultural engineering opportunities in farm management consultation by George R. Shier, consulting agricultural engineer. It is also expected to have a report at this session on the status of pending legislation affecting farm structures.

The Rural Electric program will open with a report on a state-wide farm electrification program by Morris H. Lloyd, Buffalo-Niagara Electric Corp., and the remainder of the session will be devoted to a symposium on electric welding on the farm with the following speakers listed: Hobart Beresford, University of Idaho; H. H. Beaty, Iowa State College; Delmar Bott, Madison County, Illinois, farmer; J. P. Doughlin, Westinghouse Electric Corp., and Frank Straight, General Electric Co.

The afternoon of Wednesday, June 26, will be given over to two concurrent programs; a Soil and Water program and a joint Farm Structures, Rural Electric, and Power and Machinery program.

The Soil and Water program will include the following papers: Agricultural engineering problems in watershed planning by A. W.

Zingg, Missouri State Department of Resources and Development; aerial mosaics and maps in upstream engineering, by K. M. Wood, chief, regional cartographic division, USDA; the agricultural engineer's place in the Missouri Valley development by Ivan D. Wood, USDA; and the effects of land use practices on water conservation and crop yields, by I. W. Bauer, SCS, USDA.

The joint Farm Structures, Rural Electric, and Power and Machinery program will open with a paper on coordinated design of structures and farmstead for improved efficiency by W. R. Peterson, resident engineer of International Harvester Company's experimental farm. This will be followed by a paper on the agricultural engineering phases of farm work simplification, following which there will be a panel discussion on the subject with a group of agricultural engineers selected to constitute the discussion panel. The session will close with a paper on engineering farm chores by Dawson G. Womeldorff, Public Service Co. of Northern Illinois.

The A.S.A.E. annual dinner, the real high point of the annual meetings of the Society, will be held at 6:30 p.m., on Wednesday, June 26, with Paul M. Mulliken, executive secretary, National Retail Farm Equipment Association, as master of ceremonies. Following the dinner and the presentation of A.S.A.E. medals and paper awards by Society President J. D. Long, there will be an address by Arthur C. Horrocks, director of public relations, Goodyear Tire & Rubber Co. Following Mr. Horrocks' address and the inauguration of the new president of the Society, Dr. Mark L. Nichols, assistant chief (in charge of research), Soil Conservation Service, USDA, an excellent program of entertainment has been arranged by the Committee on Local Arrangements.

Thursday, June 27. Following the meeting on Thursday, June 27, optional sight-seeing and inspection trips of recreational and agricultural engineering interest are being arranged for by the Committee on Local Arrangements and other Society members in Missouri. One of these will be a trip to the farms of the Ralston Purina Co., which will include a privately conducted inspection tour of the farms and a complimentary luncheon to those attending.

Copies of the program of the meeting and other information may be had by writing A.S.A.E. headquarters at St. Joseph, Mich. Requests for hotel reservations should be made direct to the Hotel Jefferson at St. Louis, and attendance at the A.S.A.E. meeting should be specified, as well as expected time for arrival, in asking for hotel reservations.

Rural Electric Institute Held at Amherst

THE seventh New England Rural Electrification Institute was held at Massachusetts State College at Amherst, April 15 to 18, under the sponsorship of the farm electric service committee of the New England Council.

Subjects featured included service, wiring, motors, milk coolers, refrigeration, water supply systems, irrigation, power ventilation, milking machines, sterilizers, water heaters, welding, hay finishing, poultry applications, selection of farm equipment, extension, economics of rural electrification, and viewpoints on rural electrification.

Members of the American Society of Agricultural Engineers contributing to the Institute program in cluded F. L. Rimbach, chairman of the sponsoring committee, C. I. Gunness, W. T. Ackerman, J. H. Bodwell, G. E. Mullin, H. N. Stapleton, G. M. Foulkrod, W. C. Harrington, G. L. Munroe, M. S. Klinck, Geo. W. Kable, Geo. A. Rietz, R. J. Bugbee, R. C. Proctor, A. H. Hemker, A. W. Turner, T. E. Hienton, F. E. Watts, N. D. Herrick, H. S. Smith, and E. W. Foss.

New Staff Members at Georgia

THE agricultural engineering department of the University of Georgia announces the appointment of several new staff members as follows: J. W. Simons, research professor of farm structures and utilities (cooperative with USDA); W. J. Liddell, research assistant professor of drainage and irrigation (cooperative with USDA); Lee D. Dumm, research associate in drainage and irrigation (cooperative with USDA); W. D. Kenney, research assistant in farm power and machinery; F. A. Sheriff, research assistant in irrigation, and R. R. Harris, assistant professor of farm shop and agricultural educational relations.

Recently W. E. Hudson, associate professor of farm structures and utilities, and Drayton T. Kinard, research associate professor of rural electrification, returned to the staff following an absence on account of military service.

Resignations of former members of the staff are also announced, as follows: F. B. Lanham, who has entered the wholesale hardware and building materials business at Bainbridge, Ga., and J. L. Shepherd, who has taken a post as agricultural engineer at the Coastal Plain Experiment Station, Tifton, Ga.

A.S.A.E. Officers for 1946-47

AS THE result of the regular annual election of officers of the American Society of Agricultural Engineers conducted recently by letter ballot, the following have been elected and will take office at the annual meeting of the Society at St. Louis in June:

President—Dr. Mark L. Nichols, assistant chief (in charge of research), Soil Conservation Service, U. S. Department of Agriculture.

Councilors (three-year term each), C. N. Hinkle, agricultural engineer, Standard Oil Company of Indiana, and P. T. Montfort, in charge of rural electrification, agricultural engineering department, A. & M. College of Texas.

The new Council of the Society for the year 1946-47 will include the above-named officers together with the following: R. H. Driftmier and J. D. Long, past-presidents; and F. E. Price, D. A. Milligan, W. J. Coultas, and Henry Giese, councilors.

The newly elected Nominating Committee of the Society consists of A. J. Schwantes (chairman), I. P. Blauser, and R. C. Hay. Members of the Society are invited to send any member of the Nominating Committee such suggestions as they may have for nominees for the elective offices of the Society in the next annual election, to be held early in 1947.

Beresford to Iowa; Davidson to China

ACCORDING to announcement from Iowa State College, Hobart Beresford has been named professor and head of the agricultural engineering department at that institution, effective July 1st.

Professor Beresford is a native of Iowa, an agricultural-engineering graduate of Iowa College in 1924, and has been head of the department of agricultural engineering at the University of Idaho for the past several years. He succeeds Dr. J. B. Davidson who has been head of the agricultural engineering department since 1907, with the exception of four years spent at the University of California. Dr. Davidson's retirement as department head is in agreement with the general policy of the Iowa State Board of Education that college administrative duties be relinquished at 65 years of age. Actually, he has continued his duties for a year after the normal retirement age during the difficult war years.

Dr. Davidson will continue his activities at Iowa State College as professor of agricultural engineering. He has been granted a leave of absence for a year, during which time he will serve as chief engineer of the department of agricultural engineering, Agricultural Research Bureau, Chinese Ministry of Agriculture and Forestry. In this capacity he will act as chairman of a group of four American agricultural engineers to carry on experimental and demonstrational activities in China using American production techniques. He plans to leave the United States on August 15. His appointment by the Chinese government is made possible by a special grant of funds to the Chinese government by the International Harvester Company.

Dr. Davidson came to Iowa State College in 1905 as professor of agricultural engineering and was instrumental in establishing the first four-year curriculum in agricultural engineering. He became head of the department in 1907 and served in that capacity until 1915 when he accepted a similar position at the University of California. He returned in 1919 to again become head of the department.

In testimony as to the strength of the agricultural engineering department developed under Dr. Davidson's guidance is the fact that eighteen of his former students are now heads of agricultural engineering departments in other universities and colleges.

During the war years, Dr. Davidson served as a consultant to the War Production Board on production and rationing of farm machinery and also as a consultant to the United Nations Relief and Rehabilitation Administration He was the first president of the American Society of Agricultural Engineers, and in 1933 the Society awarded him the Cyrus Hall McCormick Gold Medal for distinguished service in agricultural engineering.

In his duties as department head at the University of Idaho, Professor Beresford has been in charge of agricultural engineering research for the Idaho agricultural and engineering experiment stations and director of research for the Idaho Committee on the Relation of Electricity to Agriculture.

He is a Fellow of the American Society of Agricultural Engineers, a member of the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, and the Idaho Chapter of Sigma XI. He received the professional agricultural engineer degree from Iowa State College in 1941.

"It's rotting on the stalk,"

SAID BRUCE ARMSTRONG

"I think we can save it,"

SAID THE COUNTY AGENT

• Last fall Bruce Armstrong's 500 acres of cotton had set a wonderful crop.

He figured to pick better than a bale to the acre.

The bolls were about ready to pop when the rains came. Then, instead of opening, they began to rot. It had been a pretty rainy summer, so the cotton had put on a lot of extra leaf-growth. And the dense foliage kept it from drying out.

Bruce Armstrong was really worried when he called the County Agricultural Agent and asked him to take a look at his cotton. The County Agent came right out and he and Bruce examined each field.

"I believe it'll pay you to have it dusted by plane with calcium cyanamid right away," the County Agent said. "It's a new and fairly cheap chemical that takes the leaves off so the bolls can get light and air. I've seen it used. It stops the rot and makes cotton open."

That night Bruce called a dusting service over at Mound City and made arrangements to meet the pilot in the pasture strip across the road from his place early the next morning.

The plane dusted the 500 acres in about an hour. In less than 10 days, you could hardly find a green cotton leaf on the whole place.

Bruce Armstrong started picking on schedule. He got his bale to the acre and more. His cotton ripened so fast that he picked the whole crop in one picking.

Defoliating his cotton worked so well that Bruce told the County Agent he's going to do the same thing this year, even though the season is drier.

"It's a good way to make sure you're going to harvest all of a crop that you've worked hard to grow," said the County Agent.

"And getting advice from the County Agent is a good way to make sure that you're farming right," said Bruce Armstrong.

All over the country, farmers are getting help from their County Agents that makes farming *better* and *easier*.

Another thing that good farmers are doing to farm better and easier is to make full use of electricity.

The Modern Farm is an Electric Farm!

Electricity on the farm can make life more pleasant and work easier.

If you don't have electricity, get in touch with the electric service supplier in your area.

If you already have electricity, get your full value out of it by making it do more jobs for you.

To help build up modern farms electrically continues to be the job of the G-E Farm Industry Division.

ALL ELECTRIC MOTORS NEED THIS INEXPENSIVE STARTING SWITCH

An electric motor doesn't know when it's had enough.

Give it too much to do, too often or for too long, and it may burn itself out. For it will keep on *trying* to do the job.

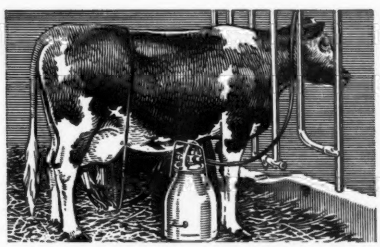
That's why every motor you use doing farm work needs the protection of a starting switch.

If you overload a motor equipped with this simple, inexpensive G-E starting switch, the device stops the motor *before* it's damaged. Then, you can reduce the load and start the motor again, just by flicking the switch off and then on.

And using a switch is also handier than using an outlet plug to start and stop a motor.

There is a G-E control providing overload protection, for every size motor you use on the farm.

Make sure that the motors you use and the appliances you buy are protected against overload damage with G-E motor control. *General Electric Company, Farm Industry Division, Schenectady 5, N. Y.*



You can cut milking time in half with an electric milking machine, and at a cost of only a few cents a month per cow.

And think of the relief you'll get from the daily drudgery of hand milking!

Take a look at today's electric milkers. They're far superior to early models. And pay particular attention to the motor on the machine you buy. Make sure that it's driven by a G-E motor. G-E capacitor motors, specially suited to milking-machine operation, have proved their reliability and long life in thousands of these laborsaving machines over a period of many years.

An electric milk cooler provides the cheapest, most convenient, and most dependable way to cool milk.

It reduces the temperature to discourage bacteria growth that might spoil your chances of getting top price. And it will keep your milk at the right temperature *automatically*, at a power-cost of only a few cents for 40 quarts of milk.

When you buy a milk cooler, make sure that it is equipped with a sturdy, dependable G-E motor and G-E control. The G-E monogram is your assurance of long-lasting, attention-free service, day in and day out.

MORE POWER TO THE AMERICAN FARMER

GENERAL ELECTRIC

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Personals of A.S.A.E. Members

Donald A. Anderson is engineer and chief of the inspection department, Refrigeration Division, Lehigh Foundries, Inc., Lancaster, Pa.

H. R. Ball is senior clerk and assistant to the stock supervisor at the Quincy, Ill., plant of the International Harvester Co.

J. Reid Bishop is now located at Granville, Ill., as associate engineer appraiser for the Federal Land Bank of St. Louis.

Thayer Cleaver was recently released from military service and has returned to his position as assistant agricultural engineer in the Division of Farm Structures and Rural Housing, BPISAE, U. S. Department of Agriculture. He is located as formerly at the University of Illinois and is engaged on corn storage investigations.

Paul C. Dillon, who served as a captain in the 271st Cavalry during the war, is now out of the service and is employed as a blockman out of the Sweetwater (Texas) branch of the International Harvester Co. His territory covers eight counties of west Texas. *(Continued on page 236)*

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Richard N. Allen, assistant agricultural engineer, Soil Conservation Service, USDA. (Mail) Box 39, Checotah, Okla.

Milo F. Arms, graduate student, agricultural engineering department, University of Nebraska, Lincoln, Neb. (Mail) 4121 Starr.

Clarence I. Branton, agricultural engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA. (Mail) Corvallis, Oregon.

Gerald W. Crowthers, rural representative, The Ohio Power Co. (Mail) 120 North Fourth St., Coshocton, Ohio.

Joseph S. Gelders, agricultural engineering division, University of California, Davis, Calif. (Mail) 418½ Second St.

Harris M. Gitlin, 478 Welch Ave., Columbus 7, Ohio.

Walter C. Gumbel, public relations, Monongahela Power Co., Fairmont, W. Va.

Herman J. Hall, assistant professor of agricultural engineering extension, University of Missouri, Columbia, Mo.

William E. Knapp, chief engineer, Minneapolis-Moline Power Implement Co. (Mail) 1420 Third Ave., Moline, Ill.

P. W. Lyon, manager, market research, Wheeling Steel Corp., Wheeling, W. Va.

Clarence J. Roberts, Jr., 18 Spring St., Tallapoosa, Ga.

Fletcher A. Sheriff, Jr., research associate in agricultural engineering, University of Georgia, Athens, Ga. (Mail) 762 Pulaski St.

George L. Stanford, engineering aid, Soil Conservation Service, USDA. (Mail) R. R. No. 1, Linden, Tex.

George E. Thompson, farmer, R. R. No. 2, Chesnee, S. C.

P. J. C. Vorster, assistant engineer, Division of Soil Conservation and Extension, Stellenbosch-Elsenburg Agricultural College, Stellenbosch, Cape V Province, South Africa.

William R. Walker, agricultural development representative, Tennessee Valley Authority. (Mail) 1035 Third National Bank Bldg., Nashville, Tenn.

Joseph A. Watson, specialist, farm production equipment, General Electric Supply Corp., 2101 Broadway, Kansas City, Mo.

Hugh C. Watts, farm practice research specialist, International Harvester Company. (Mail) GPO Box 4305, Melbourne C 2, Victoria, Australia.

TRANSFER OF GRADE

James S. Boyd, instructor in agricultural engineering, South Dakota State College, Brookings, S. D. (From Junior Member to Member)

Fred Meyer, Jr., soil conservationist, Soil Conservation Service, USDA. (Mail) Box 391, Scott City, Kan. (From Junior Member to Member).

Wiley D. Poole, assistant agricultural engineer, Louisiana Agricultural Experiment Station, Baton Rouge, La. (From Junior Member to Member)

Sam Shiozawa, assistant engineer, Rural Electrification Administration, USDA, Washington 25, D. C. (From Junior Member to Member)

J. Merle Trummel, assistant professor of mechanical engineering, University of Iowa, Iowa City, Iowa. (From Junior Member to Member)

PROFESSIONAL DIRECTORY

Personals of A.S.A.E. Members

(Continued from page 234)

Philip V. Eshelman, who served in the U. S. Naval Reserves during the war, was recently released and has accepted a position as field service engineer with the Harry Ferguson, Inc.

Robert A. Fletcher, on military leave of absence from his position with the Hyster Company for more than four years, has recently returned to his former position with the company. During the war he served as an officer in the Ordnance Department of the Army and spent 22 months overseas.

W. R. Friberg has recently joined the agricultural engineering staff of the Universithy of Idaho with the rank of associate professor. His duties will include resident instruction and extension work. During the war he served in the Army Air Force Training Command attaining the rank of major.

Charles W. Geelan was recently discharged from military service and is now engaged as district agricultural engineer for the King-Stonewall Soil Conservation District of the U. S. Soil Conservation Service at Aspermont, Texas.

Dan N. Harrell has accepted a position as farm structures specialist in the Georgia Agricultural Extension Service, for work primarily on freezer locker plants and the processing of farm products.

C. H. Jefferson is now engaged as engineer for the Vermiculite Research Institute at Evanston, Ill. He was formerly farm structures specialist in the agricultural engineering department at Michigan State College.

Walter H. Kendall is a field sales representative for the Oliver Corporation, and is located at Woodstown, N. J.

Ernest H. Kidder has returned to his work as associate hydraulic engineer for the Soil Conservation Service at Urbana, Ill. During the war he served as a lieutenant in the U. S. Naval Reserves.

A. W. Lavers, for several years chief engineer of the automotive division of Minneapolis-Moline Power Implement Co., and later industrial tractor engineer of Harry Ferguson, Inc., is now chief engineer, farm equipment division, Graham-Paige Motors Corp.

M. R. Lewis is shortly completing his work as consulting irrigation engineer on a project for the department of public works of Venezuela, and has accepted a position with the USDI Bureau of Reclamation at Boise, Idaho.

Wharton A. LeBlanc is field engineer, engaged in contacting and advising farmers, for the General Gas Corp. of Baton Rouge, La.

Edwin J. Matthews has accepted a position as instructor in agricultural engineering at the University of Tennessee.

Lester H. McGill is now a field engineer for the Lilliston Implement Co., Albany, Ga.

Richard L. Patrick was recently appointed instructor in agricultural engineering at the A. & M. College of Texas.

Grace L. Pennock, until recently connected with the Bendix Corporation is now engaged in appliance test work at the Consumer's Institute of the General Electric Co., Bridgeport, Conn.

Russell C. Shipman resigned recently as extension agricultural engineer at Purdue University to become associated with the Cooperative G.L.F. Farm Supplies, Inc., as assistant agricultural engineer in the research and development department.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEEGING indicated:

POSITIONS OPEN: FEBRUARY—O-448, 452, 464, 474, 479, 480, 481, 484. APRIL—O-488, 491, 492, 493.

POSITIONS WANTED: FEBRUARY—W-200, 207, 209, 210, 211, 227, 230, 233, 234, 235, 248, 250, 254, 267, 270, 271, 274, 282, 289, 292, 295, 296. APRIL—W-232, 237, 238, 240, 247, 253, 255, 256, 258, 262, 263, 265, 266, 269, 273, 276, 277, 281, 283, 285, 287, 290, 291, 297.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN

AGRICULTURAL ENGINEER to be in responsible charge of new agricultural engineering department in large Middle West farm management organization. Work will involve all subject matter subdivisions of agricultural engineering. Graduate agricultural engineer with good background in agricultural and agricultural engineering work preferred. Opportunity for right man to advance to high executive position. Company has liberal employment policy with pension, hospitalization, sick benefit, and stock purchase plans. Age preference 30-35. Salary $3000-$5000, depending on age and experience. O-494

ASSISTANT OR ASSOCIATE PROFESSOR of agricultural engineering for teaching and research principally in farm structures, in eastern land grant college. Prefer man with farm background; MS degree in agricultural engineering, or equivalent; some teaching and research experience, particularly in farm structures; some experience in design of structures; ability to draft, organize and carry out research projects, and ability to work with college students and farm people. Opportunity to help rebuild a department decimated by war conditions. Age—less than 40. Salary open. O-495

INSTRUCTOR in agricultural engineering for teaching and research with primary responsibility instruction in farm shop, in eastern land grant college. Prefer man with farm background, BS degree in agricultural engineering, training or experience in teaching farm shop; familiar with teacher training methods in vocational agriculture; neat and orderly in work habits; able to meet with and direct the work of college students. Opportunity for advancement to assist professor in three years. Age—less than 30. Salary $2600 to start. O-496

GRADUATE ASSISTANT in agricultural engineering, for one-half time class and laboratory teaching in various agricultural engineering subjects; one-half time study for MS degree, in eastern land grant college. Prefer man with farm background; BS degree in agricultural engineering; neat and orderly habits; ability to meet and work with college students and farm people. Opportunity to qualify for MS degree in two years. Salary $1200. O-497

AGRICULTURAL ENGINEER for research, design, and development of new ideas in farm machinery for large scale sugar cane producer in Puerto Rico. Prefer man with BS degree in agricultural engineering and considerable experience in heavy farm equipment field. House, partly furnished, provided for married man, or room and board in company hotel for single man. Salary open. O-498.

TRACTOR SERVICE MAN for operation and maintenance work in fleet of more than 100 tractors, mostly diesel, and related equipment used in large scale sugar cane production in Puerto Rico. Prefer man with actual experience in operation and maintenance of tractors and related equipment. House, partly furnished, provided for married man, or room and board in company hotel for single man. Salary open. O-499

DESIGN ENGINEER in plant manufacturing seeding, planting, and fertilizing equipment. Prefer man with BS degree in agricultural or mechanical engineering; agricultural and machine design experience; familiarity with steel, sheet metal, malleable iron, and cast iron materials and fabricating processes; interest in agricultural developments; ability to work with others; willingness to make contacts for necessary information; ability to take hold of assigned new design project, originate design, direct layout and detail draftsmen in completing design, and direct building of experimental models. Opportunities favorable as engineering department concerned in expanding. Age 30-35. Salary open. O-500

EXTENSION AGRICULTURAL ENGINEER (assistant professor rating) for full time extension work in all subject matter branches of agricultural engineering, with emphasis on farm machinery and rural electrification in eastern land grant university. Prefer man with BS degree in agricultural engineering; well grounded in farm machinery and rural electrification fields, and with some training or experience in farm buildings; and usual qualifications for extension work. Opportunity for pioneering work in state where no agricultural engineering extension work has been done to date. Salary $3200-$3600. O-501

EQUIPMENT SALES AND SERVICE MAN for work with nationally known lines in large Middle West farm management and sales organization. Prefer college graduate in agricultural engineering, with good background in corn belt farming and particular interest in sales work. Opportunity for right man to advance to executive in one of three retail sales outlets. Company has liberal employment policy, with pension, hospitalization, sick benefit, and stock purchase plans. Age 25-30. Salary open. O-502

(Continued on page 240)

PERSONNEL SERVICE BULLETIN

(Continued from page 238)

EXTENSION AGRICULTURAL ENGINEER (assistant professor rank) for work in farm machinery and buildings, in eastern land grant college. Prefer man with farm background; BS or higher degree in agricultural engineering, ability to adjust and operate ordinary farm machines for greatest efficiency; ability to write, talk at meetings and demonstrations, and organize county workers. Opportunity to advance to professor rank and head of agricultural engineering extension department. Age 25-30. Salary $3000. O-503

POSITIONS WANTED

AGRICULTURAL ENGINEER desires development, sales, or service work in power and machinery or farm structures field, with private company serving agriculture. BS deg, Kansas State College, 1943. Two years experience in farm power contracting business before completing college. Part time employment in college as undergraduate assistant in gas engine and tractor laboratory. More than two years Navy commissioned service since graduation, mostly in diesel engineering work. No physical defects. Available immediately. Married. Age 26. Salary $2800 (approx). W-300

AGRICULTURAL ENGINEER desires design, development, or research work in farm machinery, or development, sales, or service work in rural electrification. BS deg, Virginia Polytechnic Institute, 1942. Farm reared. Nearly four years commissioned service in Field Artillery since graduation. Now teaching science in rural high school, on emergency certificate. No physical defects. Available immediately. Married. Age 25. Salary $2400. W-301

AGRICULTURAL ENGINEER desires work in soil and water field; or research, development, sales or service work in farm machinery or rural electrification either with private industry or in public service. BS deg, Texas A and M College, 1943. Nine years experience in work on father's general farm immediately prior to college training. Graduation followed by more than two years commissioned service in Army Engineer Corps. Now temporarily employed in Soil Conservation Service with SP-5 rating, on surveys and drafting for drainage systems. No physical defects. Available immediately. Single. Age 25. Salary $2400. W-302

AGRICULTURAL ENGINEER desires research, design, or development work in soil and water or farm machinery field, in public service. BS deg, University of Georgia, 1942. Graduation followed by more than three years enlisted and commissioned service in Calvary and Army Ordnance. No physical defects. Available immediately. Married. Age 27. Salary $250-$300 mo. W-303

AGRICULTURAL ENGINEER desires sales or service work in power and machinery field, in private industry. BS deg, Kansas State College, expected May 19, 1946. Reared on farm and experienced in operating and servicing various types of farm machinery. College training interrupted by more than four years Army commissioned service, in Coast Artillery and in Air Corps as a fighter pilot. No physical defects. Available about May 25. Married. Age 27. Salary $3000. W-304

AGRICULTURAL ENGINEER desires teaching, research, or extension work in soil and water or farm structures field. BS deg, University of Georgia, 1943. Graduation followed by nearly three years Army service. Grounded as flying cadet in 1944 due to palpitation of heart, but now in perfect health. Available immediately. Single. Age 24. Salary $3000. W-305

AGRICULTURAL ENGINEER desires development or sales work in farm machinery or rural electrification field. BS deg in agriculture, major in agricultural engineering, Ohio State University, 1940. BS deg in agricultural engineering expected June '46. Raised on power farm. Additional experience as reporter for Ohio Bureau of Markets, two summers, in a cannery one summer, and assembling farm machinery one summer. More than five years army commissioned service in Corps of Engineers. No physical defects. Available July 1. Married. Age 29. Salary $3600. W-306

AGRICULTURAL ENGINEER desires research, teaching, or sales work in farm machinery. BS deg, Kansas State College, 1939. Graduation followed by 18 months sales and service of farm machinery, as factory representative; two years aircraft parts sales, factory office; 9 months, junior engineer, Soil Conservation Service; 30 months, seaman, Merchant Marine. No physical defects. Available immediately. Single. Age 31. Salary $300 mo. (or less in training period). W-307

CONSTRUCTION AND CONSERVATION ENGINEER desires farm structures extension work, work in a government agency, or as a construction inspector. Night school training in engineering 1937-39. Experience in farming; as surveying leader in CCC Camp; in Nebraska State Highway Engineering Dept., 1940-42; U. S. Navy Construction Battalion, 1942-46. Since January employed in U. S. Soil Conservation Service, with SP - 5 rating, on topographic and base mapping, staking out dams, etc., planting, and irrigation. No physical defects. Available three weeks after notice of employment. Married. Age 28. Salary $3000. W-309

AGRICULTURAL ENGINEER desires development or sales engineering work with manufacturer or trade association in farm building materials or equipment field. BS deg. Four months research in farm structures under Henry Giese. Two years Navy service, mostly commissioned, as assistant and chief engineer on vessel of 12,000 hp. No physical defects. Available immediately. Married. Age 23. Salary $2400. W-310

AGRICULTURAL ENGINEER desires work in soil and water conservation or reclamation field. BS deg, Kansas State College, expected May 19. Farm background and experience with farm machinery. Available about May 27. Age 25. Salary $2800. W-311

AGRICULTURAL ENGINEER desires design, research, or development work in farm machinery. BS deg, Kansas State College, expected May 19. Experience between junior and senior year in college, in employment of Boeing Airplane Co., Wichita, Kans.—July '39 to Oct. '40, punch press operator, drill press operator, layout on handmade fittings, and tool making; Oct. '40 to Dec. '41, crew chief in machine shop; Dec. '41 to Nov. '42, tool design department as designer, designer crew chief, and senior designer; Nov. '42 to Sept. '45, assistant foreman, acting foreman, and foreman. Employment terminated to complete college training. No physical defects. Available August 1, or sooner if necessary. Married. Age 33. Salary open. W-312

AGRICULTURAL ENGINEER desires design and development work in farm structures; or as project engineer in soil and water conservation. BS deg, North Dakota Agricultural College, 1943. Ten years experience in wheat farming. Part time employment in agricultural engineering department while in college. More than two years army service, enlisted, aviation cadet, and commissioned pilot in Air Corps. No physical defects. Available in June. Single. Age 24. Salary $2400. W-313